

**THE KYLE MAMMOTH PROJECT:
AN ARCHAEOLOGICAL,
PALEOECOLOGICAL AND
TAPHONOMIC ANALYSIS**

A Thesis Submitted to the College of
Graduate Studies and Research
In Partial Fulfillment of the Requirements
For the Degree of Master of Arts
In the Department of Archaeology and Anthropology
University of Saskatchewan
Saskatoon

By

Eliann W. Stoffel

Permission to Use

In presenting this thesis/dissertation in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis/dissertation in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis/dissertation work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis/dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis/dissertation.

Requests for permission to copy or to make other uses of materials in this thesis/dissertation in whole or part should be addressed to:

Head of the Department of Archaeology and Anthropology
University of Saskatchewan
55 Campus Drive
Saskatoon, Saskatchewan
S7N 5B1

Abstract

In 1964 the remains of a Woolly Mammoth (*Mammuthus primigenius*) was unearthed near the small farming community of Kyle, Saskatchewan. The salvage excavation that was conducted by the Natural History Museum of Saskatchewan (now the Royal Saskatchewan Museum) uncovered roughly twenty percent of a single animal which was determined to have died of natural causes twelve thousand years ago. No further analysis was ever conducted on the remains until now. The combination of a radiocarbon date that was obtained in 1964 that concluded a time frame congruent with Clovis occupation in North America and known Clovis occupation within the area surrounding Kyle prompted a more thorough taphonomic analysis to be conducted on the remains. The objective for the analysis was to use the identification of postmortem taphonomic markers such as intentional bone breakage patterns and cutmarks as a proxy for human intervention with the Kyle mammoth. An additional antemortem analysis was included to account for a healed lesion that was discovered on a thoracic vertebra. The cause of the lesion, although not concluded, raises questions as to human association with this particular mammoth as well as a pathological aspect relating to a well-documented phenomenon that occurred in Eurasian Woolly Mammoths. The addition of an osteological analysis sheds light on the species, sex, and age at death of the animal and an archaeological and paleocological background supplements the notion of human and proboscidean interactions by shedding light on the environment surrounding the area of Kyle roughly 12,000 years ago and the possibility of the two species coexisting in southwestern Saskatchewan.

Acknowledgments

I would like to thank my supervisor Dr. E. Walker along with my supervising committee Dr. M. Kennedy and Dr. A. Aitken on their guide and support throughout the process of my thesis. I would like to thank the Royal Saskatchewan Museum and more specifically Tim Tokaryk, Ryan McKellar, and Wes Long for allowing me to access the bones and helping me handle them as well. I would like to thank the community of Kyle for their enthusiasm and support for the project including Barb Pierce, Jack Kerr, Dan Zazelenchuk, and the Gundersons who allowed me to dig a trench on their land for this project. In addition, I would like to thank Katie Burdeyney, Dr. E. Walker, and Dr. G. Stuart and his kids for coming out on a cold Saturday to help take sediment samples and profile the trench near Kyle. I would like to thank the Saskatchewan Heritage Foundation, the Saskatchewan Archaeological Society, and the Department of Archaeology and Anthropology for supporting me financially through grants, scholarships, and fellowships. I would like to thank my fellow classmates in the Department of Archaeology and Anthropology at the University of Saskatchewan for helping to keep spirits at an all-time high over the years and for keeping me company on many treks to Tim Hortons for a caffeine fix. I would like to thank Jenn and Katie for being constantly at school for me so that I was never lonely in the lab when I would show up and for always having something positive to say or listen when I needed to rant. Lastly, I want to thank my family (Shaun, Marten, Regina, Moyca, Pieter, Oma, Opa, and extended aunts and uncles) who took interest, aided me financially, and encouraged me to finish strong. Thank you Shaun for not allowing me to procrastinate like I usually do. You know me too well!

Table of Contents

Permission to Use	i
Abstract.....	ii
Acknowledgments	iii
Table of Contents	iv
List of Tables	vi
List of Figures.....	vii
List of Abbreviations.....	x
Chapter 1	1
Introduction	1
1.1 Excavation History	2
1.2 Methods	9
Chapter 2	12
Clovis Complex and Mammoth Kill Sites.....	12
2.1 Clovis Sites with Mammoth Association	13
2.1.1 Blackwater Draw Locality No. 1	13
2.1.2 Colby.....	16
2.1.3 Dent.....	16
2.1.4 Domebo.....	16
2.1.5 Hebior	17
2.1.6 Kimmswick.....	17
2.1.7 Lange-Ferguson	18
2.1.8 Lubbock Lake	18
2.1.9 Miami.....	18
2.1.10 Pleasant Lake	19
2.1.11 Naco, Murray Springs, Escapule and Lehner	19
2.2 Clovis Sites with Possible Mammoth Association.....	21
2.2.1 Claypool.....	21
2.2.2 Cooperton.....	21
2.2.3 Fetterman	23
2.2.4 Lindsay.....	23
2.2.5 Schaefer.....	24
2.2.6 Selby/Dutton	24
2.2.7 Jensen.....	24
2.2.8 La Sena.....	25
2.2.9 Lovewell	25
2.3 Clovis in Saskatchewan.....	26
Chapter 3	28
Biophysical Background.....	28
3.1 Bedrock Geology.....	28
3.2 Glacial Retreat	29
3.3 Proglacial Landscape.....	33
3.4 Trench Profile Summary	35
3.4.1 Plough	35
3.4.2 Silty Clay	35

3.4.3	Carbonate Clay.....	36
3.4.4	Iron Stain I.....	36
3.4.5	Blocky Clay	38
3.4.6	Iron Stain II.....	38
3.4.7	Upper Section.....	38
3.4.8	Lower Section.....	39
3.5	Biophysical Background.....	40
3.6	Paleoecology.....	41
3.6.1	Flora.....	41
3.6.2	Fauna.....	43
3.7	Summary.....	45
Chapter 4	46
Osteological Analysis	46
4.1	Axial Skeleton	48
4.2	Appendicular Skeleton	53
4.3	Bone Fragments.....	55
4.4	Sex	56
4.5	Age at Death.....	57
4.6	Taxonomy.....	59
4.7	Summary.....	64
Chapter 5	65
Taphonomic Analysis	65
5.1	Postmortem Taphonomy.....	65
5.1.1	Natural Taphonomy	65
5.1.2	Modern Anthropogenic.....	70
5.1.3	Butchering.....	71
5.1.4	Taphonomic Features of the Kyle Mammoth	75
5.2	Antemortem Modification	77
5.2.1	Trauma	78
5.2.2	Pathological.....	81
5.3	Summary.....	86
Chapter 6	88
Conclusion	88
Appendix A	92
Appendix B	98
References Cited	120

List of Tables

2.1 Confirmed Clovis and Mammoth Association	15
2.2 Possible Clovis and Mammoth Association	22
4.1 Bones Recovered of the Kyle Mammoth.....	47
4.2 Long Bone Epiphyseal Fusion State	59
4.3 Molar Radiometrics for the Kyle Mammoth vs Maglio’s (1973) Measurements	62
5.1 Stages of Bone Weathering by Behrensmeyer (1978) on the Kyle Mammoth.....	66
5.2 Identifiable Natural Taphonomic and Modern Anthropogenic Marks	72
B.1 Landmark Measurements for P 1699.1 8810 B.....	99
B.2 Landmark Measurements for P 1699.1 8810	100
B.3 Landmark Measurements for 1699.1 8810 C.....	101
B.4 Landmark Measurements for P 1699.1 8810 Display.....	102
B.5 Landmark Measurements for P 1699.1 8810 F	103
B.6 Landmark Measurements for P 1699.1 8810 I.....	104
B.7 Landmark Measurements for P 1699.1 8810 E.....	105
B.8 Landmark Measurements for P 1699.1 8810 G	106
B.9 Landmark Measurements for P 1699.1 8810 J.....	107
B.10 Landmark Measurements for P 1699.1 8810 H	108
B.11 Landmark Measurements for P 1699.1 8810 K	109
B.12 Rib 1 Measurements.....	111
B.13 Rib 2 Measurements.....	112
B.14 Measurements for the Mandible.....	113
B.15 Measurements for the Scapula	114
B.16 Articulated Forelimb Measurements.....	116
B.17 Right Femur Measurements	117
B.18 Right Hindlimb Measurements	118
B.19 Tusk Measurements.....	119

List of Figures

1.1 The location of Kyle, Saskatchewan.....	2
1.2 Femur of the Woolly Mammoth being uncovered in 1964 west of Kyle, Saskatchewan.	5
1.3 Bone fragment being wrapped in burlap dipped in plaster of Paris in preparation for transportation in 1964 in Kyle, Saskatchewan.	5
1.4 Aerial view of the Kyle mammoth excavation in 1964.	7
1.5 Distorted sediments indicating a highly dynamic landscape at the time of the Kyle mammoth.	7
2.1 The Locations of Mammoth Archaeological Sites.	14
3.1 Ice frontal positions simplified by Turner et al. (2004) in Saskatchewan	32
3.2 Sediment profile in Kyle Saskatchewan depicting the six sediment layers described.	36
3.3 Kyle sediment profile simplified.	37
4.1 Schematic representation of the bones recovered of the Kyle mammoth.....	47
4.2 Original Site Map (1964) Bones Recovered by SMNH: #1- Bone Fragments (unidentified HI= 4.0'), #2- Foot Bones (5.2' b.d.), #3- Foot Bones (4.0'-5.4' b.d.), #4- Back of rib Fragments, #5- Fragmentary knob of Long Bone (wrapped), #6- Vertebrae, #7- Vertebrae in Block, #8- Vertebrae with upright spine, #9- Molar tooth (First found 3.5' b.d.), #10- Misc. unidentified Bones, #11- Rib, #12- Femur (5.0' b.d.), #13- blank, #14- Rib (3.6' b.d.), #15- Vertebrae (group of 3 articulated 4.2' b.d.), #16- Foot (5.9' b.d.), #17- Rib, #18- Vertebrae, #19- Tusk (3.9- 6.6 b.d), #20- blank, #21- Jaw (5.6' b.d.), #22- Scapula (5.5' b.d.), #23- Vertebrae (collected for C-14 sample Oct. 26 1964 by T. F. Kehoe 6" sent to C-14 Lab Saskatoon Oct. 31 1964. 6" below distal end of scapula. Extra carbon 14 sample in SMNH drawn (?) F16	49
4.3 Superior portion of scapula showing billowing indicating ossification has not occurred yet.	60
4.4 Proximal (A) and distal (B) femur showing prominent billowing indicating that epiphyseal ossification had not occurred.....	60
4.5 Location of measurements taken on the lingual surface of M ₆	63
4.6 Location of measurements taken on the occlusal surface of M ₆	63
5.1 Spongy bone from fragment box exhibiting several straight grooves determined to be vessel impressions.	76
5.2 Rib fragment from box P1699.11 8810 with hinge fracture indicated by the green arrow. Inconclusive origin.	76

5.3 The lesion exhibited on the lower thoracic vertebra of the Kyle mammoth (1699.1 8810 J) a)The vertebra as a whole. b) Zoomed in with smaller lesion seen through the larger as indicated by the white arrow	78
5.4 Radiograph of the vertebra presenting the lesion in the right transverse process. The presence of cortical bone surrounding the lesion as indicated by the green arrows indicates a healed lesion.....	79
5.5 Bone/Ivory rod cast inserted into the lesion showing the possibility that a weapon may have cause the lesion on the thoracic vertebra	82
5.6 Osteolytic lesion on the left transverse process on the posterior aspect. Indicated by the white arrow.....	85
5.7 Osteolytic lesion on the right facet of the interior articular process. Indicated by the white arrow.....	85
5.8 Osteolytic lesion on the central axis of the spinous process on the caudal surface. Indicated by the white arrow.	85
A.1 Deglaciation Outline: 14 ka BP (Dyke et al. 2003).	93
A.2 Deglaciation Outline: 13 ka BP (Dyke et al. 2003).	93
A.3 Deglaciation Outline: 12 ka BP (Dyke et al. 2003).	94
A.4 Deglaciation Outline: 11.5 ka BP (Dyke et al. 2003).	94
A.5 Deglaciation Outline: 11 ka BP (Dyke et al. 2003).	95
A.6 Deglaciation Outline: 10.5 ka BP (Dyke et al. 2003).	95
A.7 Deglaciation Outline: 10 ka BP (Dyke et al. 2003).	96
A.8 Deglaciation Outline: 9.5 ka BP (Dyke et al. 2003).	96
A.9 Deglaciation Outline: 9 ka BP (Dyke et al. 2003).	97
B.1 Posterior (A) and anterior (B) view of cervical vertebra P1699.1 8810 B.....	99
B.2 Posterior (A) and anterior (B) view of thoracic vertebra P1699.1 8810.....	100
B.3 Posterior (A) and anterior (B) view of thoracic vertebra P1699.1 8810 C	101
B.4 Posterior (A), anterior (B) and lateral (C,D) views of thoracic vertebra P1699.1 8810 Display.....	102
B.5 Lateral (A,C), posterior (B), and anterior (D) views of thoracic vertebra P1699.1 8810 F..	103
B.6 Posterior (A), anterior (B) and lateral (C,D) views of thoracic vertebra P1699.1 8810 I.....	104
B.7 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 E...	105

B.8 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 G ..	106
B.9 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 J....	107
B.10 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 H.	108
B.11 Lateral (A,B), posterior (C) and anterior (D) views of lumbar vertebra P1699.1 8810 K..	109
B.12 Cranial (A) and caudal (B) sides of a spinous process P 1699.1 8810 D. Maximum length of the spinous process is 516 mm.	110
B.13 Two sides of incomplete rib 1.	111
B.14 Rib 2 cranial (A) and caudal (B) sides.	112
B.15 Lingual (A), buccal (B), and occlusal (C) sides of the right mandible.	113
B.16 Right Scapula lateral view.....	114
B.17 Right distal humerus caudal (A) and lateral (B) views. No measurements presented due to incompleteness.....	115
B.18 Right distal radius inferior (A) and lateral (B) views. No measurements presented due to incompleteness.....	115
B.19 Right distal ulna inferior (A), lateral (B), and caudal (C) views. No measurements presented due to incompleteness.	115
B.20 Right articulated forelimb, cranial (A) and caudal (B) views.	116
B.21 Right unfused femur from caudal (A), medial (B), and cranial (C) views.	117
B.22 Right articulated hindfoot including tarsals.	118
B.23 Tusk photographed on shelf due to fragile state. The three photographs depict a single tusk at different position along its length.	119

List of Abbreviations

- 3:** Length between Goc and aboral border of M₆ alveolus.
4: Arboal border of alveolus of M₆ to Id.
5: Goc to Id.
6: Length of the alveolar cavity lingual.
19: Height of ramus.
20: Height of ramus between coronoid and condyle.
21: Oral height of ramus (to coronoid).
22a: Height of mandibular body posterior to M₆.
22b: Height of mandibular body anterior to M₆.
Bd: Breadth of distal end.
BFcd: Breadth of the Facies terminalis caudalis.
BFcr: Breadth of the Facies terminalis cranialis.
BG: Breadth of glenoid angle.
Bp: Breadth of proximal end.
BPacd: Breadth across the Processus articulares caudalis.
BPacr: Breadth across the Processus articulares cranialis.
BPtr: Breadth across the Processus transversi.
BTr: Breadth of region of the Trochanter tertius.
CD: Smallest circumference of diaphysis.
Cr: Coronion- highest point of the coronoid.
DC: Greatest depth of Caput femoris.
DHA: Diagonal Height (distal point to thoracic angle).
GL: Greatest length.
GLC: Greatest length from femoral head.
GLP: Greatest length of the Processus articularious (glenoid).
GLPa: Greatest length from the Processus articulares cranialis to the Processus articulares caudalis.
Goc: Conion caudale- aboral point of the mandibular angle.
H: Height
HFcd: Height of the Facies terminalis caudalis.
HFcr: Height of the Facies terminalis cranialis.
HS: Height along spine.
I: Incomplete.
Id: Infradentale- most anterior point of alveolar cavity.
Ld: Dorsal Length.
LG: Length of Glenoid cavity including lip.
PL: Physiological length of the body.
SD: Smallest breadth of diaphysis.
SLC: Smallest length of the Collum scapulae.

Chapter 1

Introduction

Evidence of Clovis procurement of proboscideans is uncommon on the Great Plains and even more difficult to distinguish if no archaeological remains are apparent. Only a handful of sites have confirmed direct human association with megafauna and only a few more have circumstantial evidence of human involvement (Grayson and Meltzer 2002; Holen 2006, 2007; Joyce 2014; Waguespack 2007). In the latter cases, a taphonomic study in the absence of Clovis or pre-Clovis connection serves as a proxy for their involvement in the procurement of megafauna (Holen 2006, 2007, 2014). Even then, lines of inquiry, such as the nature of human existence in North America in regards to pre-Clovis, are not solidified enough to corroborate the evidence found on the extinct fauna. Further research in taphonomic processes on proboscidean remains and Clovis and pre-Clovis occupation on the Great Plains of North America can provide further insight into determining procurement strategies used by humans on extinct megafauna.

Located on the northern periphery of the Great Plains, the remains of a Woolly Mammoth (*Mammuthus primigenius*) discovered near the community of Kyle, Saskatchewan (see Figure 1.1) provides an opportunity to investigate two questions: (1) is there a possible Clovis and proboscidean association on the northern Great Plains, and (2) can an applied taphonomic study determine if any of the identified taphonomic markers on the remains be evidence of human procurement strategies?

This study includes a multidisciplinary research approach in regards to the mammoth remains found in Kyle. First and foremost, the bulk of this thesis addresses a taphonomic investigation of the remains to identify any and all taphonomic indicators whether human-induced or natural. This also includes a basic osteological analysis in order to determine the sex, age at death, and the species of the mammoth. In addition, a glacial geological and paleoecological background of southern Saskatchewan will supplement the study by providing an environmental context that will show an ecosystem conducive for the relative survival of both mammoths and humans. As well, reference needs to be made to comparable sites on the Great

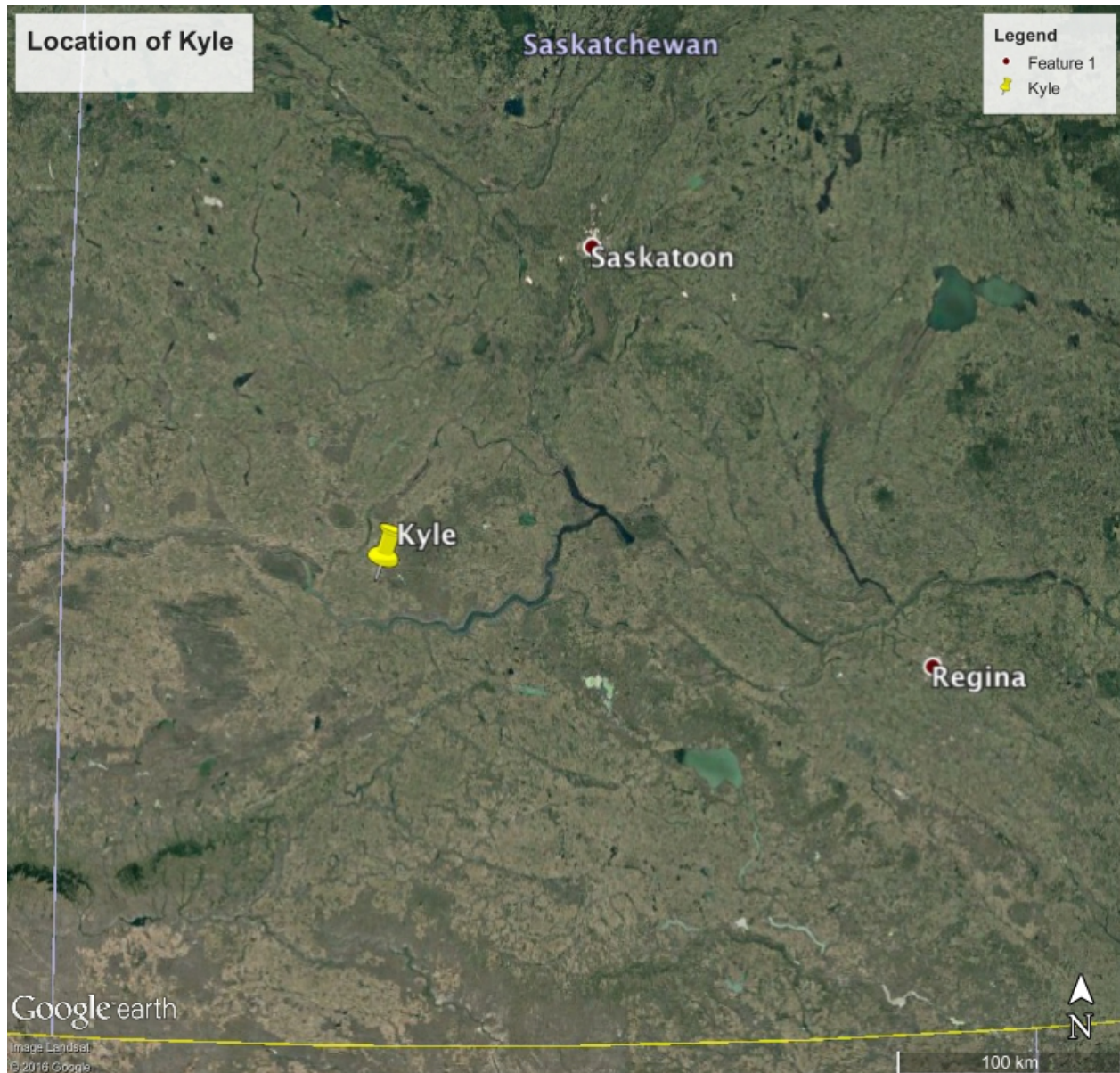


Figure 1.1 *The location of Kyle, Saskatchewan.*

Plains employing a similar study of proboscidean remains. Ultimately, a conclusion will be reached that will provide further knowledge regarding proboscidean and human relationships and will supplement the very sparse information there is on this subject with the addition of a Saskatchewan perspective.

1.1 Excavation History

The historical accounts of the salvage excavation that was conducted near Kyle were compiled using local newspaper clippings collected by Ruth and Heron Fulton of the Saskatchewan Archaeological Society in 1964 and 1965. Unfortunately, the titles of the

newspapers featuring the excavation were not included with the clippings. The following events are extracted from these articles unless indicated otherwise. A caution must also be noted here. The stories written in these newspaper articles are interpreted to be an attempt to provide the most factual information of events to its reader. It is with this caution that the reader of this thesis keep in mind that all the information presented here may contain erroneous statements. Regardless of errors, all facts presented here are unaltered pieces of information that were presented in the initial publications of the newspaper articles and may not correlate to the findings presented later on. This is the nature of reporting the news.

On October 17, 1964, William McEvoy of Lacadena, Saskatchewan and the rest of his municipal road crew were working on elevating the road grade on Railway Avenue, three and a half miles west of Kyle, Saskatchewan. While scraping the south side of the road with his bulldozer, he noticed something unusual coming out of the ground in front of the tractor blade. He immediately ceased operations and went to investigate. The sheer size of the object, which he thought was bone, prompted him to call local authorities. Police determined that a more professional investigation was needed in order to identify the object and so local amateur archaeologist Gordon Millword was called to investigate. Gordon called on Ken Cronk, executive secretary of the Saskatchewan Archaeological Society, to assist him in the identification. The men immediately made their way to the site. On October 18 they called Dr. Thomas Kehoe, archaeologist with the Natural History Museum (now the Royal Saskatchewan Museum) in Regina, to come out and confirm the find. By October 19, Dr. Kehoe was heading to the site with a crew of three including himself, together with assistant archaeologists Eugene Gryba, Gil Watson, and paleontologist Albert Swanson, all from the museum.

Excavation on the bones began on October 19, 1964 and by October 21 Dr. Kehoe had confirmed the find of a Pleistocene proboscidean more commonly known as the North American Woolly Mammoth. For the next nine days, the crew from the Natural History Museum and volunteers from the Saskatchewan Archaeological Society excavated to uncover what is still to date the most complete skeletal collection of a Woolly Mammoth found in Saskatchewan.

Excavation of these remains was difficult from the very beginning. A hard clay matrix proved arduous for the excavators as work needed to be delicate. Ice picks, trowel, small knives, and geological tools aided in this difficult task and yet conditions only worsened when the bones were exposed to air. Dr. Kehoe described the bones in a small excerpt written to the

Saskatchewan Archaeological Society (1964), post-excavation, that the bones began to crumble when the clay was removed. In order to keep the bones from deteriorating further, a shellac mixture was applied using paintbrushes. Alcohol mixed with the shellac shortened the drying time of the shellac so that excavations could continue in a timely manner (Figure 1.2). Further support was provided for the remains in the form of burlap dipped in plaster of Paris once the majority of individual bones were exposed. Excavators first applied a paper protection to the bones and then the excavators wrapped burlap around individual bones with a small amount of underlying matrix attached (Figure 1.3) (Kehoe 1964). A total of 18 casts was carefully made and encased elements such as the upper molar, an almost complete lower jaw with an intact molar, a femur, three articulated feet, eight vertebrae, several rib fragments, a scapula, and a tusk (Kehoe 1964; Dr. T. Kehoe to Dr. W.O. Kupsch, letter, 13 November 1964, Royal Saskatchewan Museum, Regina).

Given that the team from the museum was comprised of mainly archaeologists, the search for Clovis material in the form of tools or projectile points, was part of the reason for the delicate excavation strategy. Screening of the excavated sediments was not carried out due to time constraints, but projectile points found from the Kyle region drew attention to the search for any evidence of cultural material among the mammoth remains. None was found. Owing to the lack of human intervention in the form of discarded tools, Dr. Kehoe determined that the animal died of natural causes.

The meticulous nature of the excavation served two purposes. First, the mammoth was removed in the best possible preservable fashion, so that secondly, a radiocarbon sample could be obtained that was free of contamination. The last bone recovered, a vertebra, was located only inches below the scapula and was directly transferred to aluminum foil using a clean steel trowel upon exposure. No shellac was applied and no burlap covered the bone (Dr. T. Kehoe to Mr. William Irving, letter, 30 November 1964, Royal Saskatchewan Museum, Regina). The sample was initially distributed to three institutions so that a cross-check could be conducted to verify an estimated radiocarbon date. These institutions included the National Museum of Canada in Ottawa, Ontario; the Chemistry Department at the University of Saskatchewan in Saskatoon, Saskatchewan; and a sample sent to the Geochronology Laboratory at the University of Arizona in Tucson, Arizona (Dr. K.J. McCallum to Dr. T. Kehoe, letter, 15 February 1965, Royal Saskatchewan Museum, Regina; Dr. T. Kehoe to Dr. C. Vance Haynes, letter, 18 April 1966,



Figure 1.2 Femur of the Woolly Mammoth being uncovered in 1964 west of Kyle, Saskatchewan.



Figure 1.3 Bone fragment being wrapped in burlap dipped in plaster of Paris in preparation for transportation in 1964 in Kyle, Saskatchewan.

Royal Saskatchewan Museum, Regina). It was later realized by the Chemistry Department at the University of Saskatchewan that the entire two-pound vertebra was needed in order to produce a radiocarbon date. The sample that was sent to Ottawa was returned to the University of Saskatchewan's Chemistry department to the radiocarbon dating laboratory (Dr. T. Kehoe to Dr. J. Fyles, letter, 29 January 1965, Royal Saskatchewan Museum, Regina). Dr. K. J. McCallum head of the Department of Chemistry and technician J.K. Wittenberg performed the test, which took 6 months to run (Local Newspaper 1965; Dr. T. Kehoe to Dr. K.J. McCallum, letter, 17 March 1965, Royal Saskatchewan Museum, Regina;). The date returned for the Kyle mammoth was $12,000 \pm 200$ years B.P. (S-246) (Dr K.J. McCallum to Dr. E.A. Christiansen, letter, 11 March 1965, Royal Saskatchewan Museum, Regina; McCallum and Wittenberg 1968; Morlan 2001). The sample that was sent to Arizona was dated at $8,650 \pm 400$ years B.P. (A-619), but was determined to be erroneous. The examiners and author did not extrapolate as to the origin of the error (Morlan 2001).

Dr. E. Christiansen of the Department of Geology and Saskatchewan Research Council at the University of Saskatchewan visited the site (Figure 1.4) during excavations to provide an interpretation for the depositional environment surrounding the mammoth remains. He concluded that the mammoth was initially deposited in a proglacial pond (Figure 1.5), called a kettle lake or pothole, which was located on glacial till underlain by stagnant ice (Kehoe 1964). After the pond dried, erosional processes degraded the bones creating the powdery texture the excavators were experiencing. Stagnant ice melt began to distort the pond sediments and exposing the mammoth remains (Pettipas 1975). Further retreat of the glacier caused an inundation of meltwater throughout the region creating a large proglacial lake. Clay settling at the bottom of the lake buried the remains under immense amounts of fine sediment. Subsequent draining of the lake left a low topographic relief landscape seen today with extremely fertile ground and exposed the newly deposited glaciolacustrine clays to erosional processes until present times (Kehoe 1964).

Dr. Christiansen was not the only visitor to stop by the site during excavation. The unique nature of a mammoth finds in Saskatchewan drew large crowds of curious people. By the Tuesday after the initial find, Dr. Kehoe and Dr. E. Christiansen began to address the crowds congregating to see the excavation explaining the work that was being conducted. He estimated that roughly 1000 people had already come by the site. These included mostly students who



Figure 1.4 Aerial view of the Kyle mammoth excavation in 1964.



Figure 1.5 Distorted sediments indicating a highly dynamic landscape at the time of the Kyle mammoth.

were brought in from the surrounding district. By October 20, the numbers slowly increased to 5000 people and another 2000 were reported to have visited by the weekend, forcing excavators to rope off the excavation site to prevent visitors from disturbing the bones. Eldon Johnson, President of the Saskatchewan Archaeological Society, took over addressing the crowds that came in to see the excavation. Dr. Kehoe expressed his gratitude to those who helped in a document:

The success of this project was due largely to the hard work of Saskatchewan Archaeological Society members who volunteered to aid the Museum crew (Kehoe, Gryba, G. Watson and Albert Swanson). We sincerely thank: Eldon Johnson (Kindersley), Phil Rayner (Lancer), Tom Smith and Tom Phenix (Saskatoon), Gordon Millward (Kyle), Raymond and Gilbert Gill and N. and C. Nagel (Leader), Bill Marjerrison and Don Bone (Greenan), Don Heron (Swift Current), and Rev. McLean and his son, from Eston. Fred Lahrman was chief photographer. Gratitude is also due to Harvey Beck, Curator of Zoology at the Saskatchewan Museum, who sacrificed a Sunday to guide the thousands of visitors at the site. And we are pleased to express our appreciation to those twenty thousand people, who were remarkably considerate, a credit to the intelligence of Saskatchewan's population. [Kehoe 1964]

By the end of the excavation an estimated 20,000 visitors had stopped by the site to see the remains (Kehoe 1964).

The excavation area was eventually expanded to 4.8 m by 4.2 m across the ditch to ensure all of the bones were found. Excavators began digging at the depth of the tusk, approximately 1 m below the surface, until the last bone was pulled out at 2.4 m below the surface. A theodolite was used to situate all the larger bones onto a roughly sketched map. After excavations were concluded the casts encasing the bones were transported to Kyle where they were stored in a shed to fully dry, a period which took three weeks. F.G. Bard, director of the Natural History Museum overseeing the entire project, picked up the casts after the drying period and transported them to the museum in Regina. Some of the casts were so large and heavy a hydraulic lift was needed in order to load them onto the truck. The intention of the directors from the Natural History Museum was to reconstruct the mammoth from the bones that were excavated. They had discussed displaying either an anatomical mammoth in the museum based on the bones found at Kyle or to recreate the excavation within a display to represent the delicate work of archaeological and paleontological excavations. So far only plaster casts have been made of the tusk, femur, a vertebra, and the lower jaw with a molar, which are on display at the museum in Regina and Kyle.

The excavation of a Woolly Mammoth in Kyle, Saskatchewan is one of great importance to the province. Dr. Kehoe and his crew from the museum along with the volunteers from the Saskatchewan Archaeological Society put in long hours on the cold open prairie in order to salvage the mammoth. The success of the excavation has led the community of Kyle to adopt the mammoth as part of a symbol of their identity even dubbing him with the name 'Wally'. A statue of 'Wally' can be seen at the entrance to Kyle on the north end of the town and was constructed by Saskatoon Artist Don Foulds in 1981 for the town of Kyle. The mammoth still remains to this day an attraction when visiting the town of Kyle and the skeletal remains are still accessioned at the Royal Saskatchewan Museum in Regina.

1.2 Methods

The methods employed for this study are very straightforward. The field methods used in 1964 have already been described. A second field excursion was conducted in November 2015. A trench was excavated near the original site of the mammoth to obtain a stratigraphic profile and sediment samples that will be used for a pollen analysis. Dr. Glenn Stuart, an environmental archaeologist of the Department of Archaeology and Anthropology at the University of Saskatchewan, will be conducting the pollen analysis on fourteen sediment samples that were taken from the trench. However, the results from the pollen analysis are not part of this thesis.

The location of the trench was chosen based on two factors: (1) proximity to the original excavation area and (2) the area showed little sediment disturbance due to agriculture or infrastructure. The trench was dug approximately 100 m from the recorded location of the mammoth remains. A backhoe was brought in to dig the trench since the depth recorded from the initial excavation was roughly 2.4 m. The profile was drawn using a centerline roughly halfway down the wall due to the depth of the trench. Measurements of sediment layers on the southern wall were taken from the centerline and drawn on graph paper, which was subsequently entered into Microsoft Excel and a graph representing 3 m of profile was produced (Figure 2 Chapter 2). Sediment samples were taken using a sterilized trowel and deposited into paper bags that were labelled accordingly and recorded on the profile drawing.

The osteological analysis required the identification and measurements of skeletal elements. Comparative images by Olsen (1979) were used to recognize and side the elements that were identifiable. If possible, measurements of bones were done using Von Den Driesch's (1976) standardized measurements of animal bones so that a published comparative study of this

specific animal was available for subsequent research. In addition, Roth's (1984) and Lister's (1999) publication on growth markers on epiphyseal surfaces, Jachmann's (1988) and Laws (1966) estimations of ages in elephants, and Roth and Shoshani's (1988) discussion on age determination on Asian elephants were referenced to aid in determining the age at death. Since it is no longer possible to observe the growth of Woolly Mammoths and there is a lack of complete mammoth remains representing stages of growth, modern studies conducted on African Elephants and Asian elephants are commonly used to study comparative growth patterns. Sex determination was done using radiometrics from the tusk and species was determined using radiometrics of the third molar set out by Maglio (1973).

The methods used in the taphonomic study required comparative observation of marks left on the bones. Three categories of taphonomic processes were created in order to describe each marker identified. Natural taphonomic processes define the first category; this includes biological or weathering related indicators. For example, root etching is defined as biological while degradation of the bones is an example of weathering due to exposure to erosional processes. Anthropogenic taphonomic processes make up the second category; this is described as modern anthropogenic processes and includes accidental trowel knick marks created during excavation as an example. The last category encompasses butchering marks that define a subsistence strategy utilized by Paleoindian people. The last category requires careful analysis and comparison to well-documented examples of butchering marks on proboscidean remains (e.g. Frison and Todd 1986; Hannus 1985; Haynes 1991; Holen 2006, 2007; Holen and Holen 2014). Further discussion will be presented for any bone falling in the last category making reference to possible explanations that may debunk the taphonomic markers found. Sites that have published well-documented evidence of butchering need to be acknowledged and summarized first in order to establish a proxy to be used in the taphonomic analysis when regarding the last category. The following chapter summarizes 23 sites with this evidence along with the accompanying Clovis technocomplex.

The objectives of this thesis fall in four areas of concentration. The first has already been presented in section 1.1 under the accounts of the historical excavation. This was to establish the significance of the find within the community of Kyle and to the province of Saskatchewan. The second is to conduct a paleoecological study of the environment surrounding the Kyle mammoth's final resting place as part of Dr. Christiansen's initial interpretation of the geological

history of the area. The third objective is to conduct an osteological analysis of the Kyle mammoth bones to determine physiognomic features. The last objective is to conduct a taphonomic analysis to evaluate if human interaction (i.e. Clovis) is evident on the bone. The outline for the thesis is thus presented in that order. The introductory chapter includes the short history of the salvage excavation conducted in Kyle. Chapter two establishes the proxy needed for the taphonomic analysis by studying sites with proven or probable evidence for human proboscidean interaction. Chapter three delves into the paleoecological background for the Kyle mammoth while chapter four establishes the mammoth's physical characteristics. Chapter five investigates the taphonomic analysis in search for evidence of human association with chapter six finishing the thesis with concluding remarks about the taphonomic analysis.

Chapter 2

Clovis Complex and Mammoth Kill Sites

Clovis is the oldest and geographically most visible technocomplex known in North America (Miller et al. 2014; Holliday and Miller 2014). A fairly large and heavy lanceolate biface point made from high-quality raw materials best denotes the complex. Its lanceolate shape is defined with a slightly convex to parallel lateral edges and flutes that extend no further than halfway from the base along the midridge. The length varies between 75mm and 110mm with a width ranging from 25mm to 50 mm. The base is slightly concave in nature and reaches a depth of 1 to 4 mm (Howard 1990). Each flute is constructed from a single or multiple flakes and presents on one or both faces of the point. The base and lower lateral edges are ground smooth to allow for hafting on a spear or foreshaft. Other diagnostic specimens found in the Clovis toolkit consists of prismatic blades, large biface preforms, scrapers, and graters. Spurred scrapers and bone rods have also been included in the toolkit with nearly 50% of sites containing fluted projectile points also containing spurred scrapers (Rogers 1986). Bone rods may be beveled at either ends or just one end and have been considered to be part of the foreshaft mechanism. The accepted date range for Clovis has been refined to 11,600 – 11,000 yr B.P. in the Southern Plains and 11,200 – 10,900 yr B.P. on the Northern Plains (Haynes 1992, 1993; Holliday 2000; Miller et al. 2014).

The quality of the tool kit created during the Clovis period is reflective of the efficiency of the hunting. Although opportunities for scavenging may be available, Clovis hunters would have been very skilled at hunting megafauna. If the assumption were to be made that mammoths behaved much like modern African elephants, then the supposition can be inferred that there was a matriarchal structure to mammoth herds. Opportunities for Clovis hunters would be presented when a small group or a single mammoth would become separated from the main herd and away from the protection of the matriarch (Frison 2004; Kornfeld et. al 2010). Even in this hypothetical situation, taking down a single mammoth would require a substantial amount of

patience and skill. A charging mammoth could not be killed with a single spear throw to the head as the cranium requires a massive amount of force to penetrate. The target would need to be in between the ribs as vital organs are only a few inches below the flesh and could easily be nicked causing a lethal wound. Even after being struck, the mammoth could survive for a substantial amount of time before dying from its injuries (Frison 2004). The Clovis projectile point is well suited to provide the fatal wound as the very sharp edges allow the point to penetrate down to the organs while the lenticular structure of the point strengthens against the force of impact caused by a thrusting or throwing force. The basal flute and grinding both aids in making the haft easy and strong as well as to protect the bindings from being cut upon impact (Kornfeld et al. 2010).

2.1 Clovis Sites with Mammoth Association

It is evident that Clovis hunters were well adapted for hunting megafauna as sites containing Clovis material have been conclusively found in direct association with mammoth and mastodon remains (see Figure 2.1). Grayson and Meltzer (2002) have recognized fourteen sites out of a possible seventy-six south of the Laurentide Ice Sheet that are indisputably associated with Proboscidean hunting. The majority of the sites listed in Table 2.1 are in direct association with the Clovis tool kit and some denote evidence of butchering marks on extinct megafauna bones. Radiocarbon dating for the majority establishes a distinct correlation between the known presence of Clovis culture in North America and the existence of megafauna.

2.1.1 Blackwater Draw Locality No. 1

Also known as the Clovis type site in eastern New Mexico, Blackwater Draw boasts a large number of kill sites surrounding a permanent watering hole during the period of 15,000 to 6,000 years before present. Five mammoths (*Mammuthus columbi*) were found in direct connection with Clovis projectile points with an additional seven mammoths found in the same gravel pit but without artifact associations. The evidence indicates that these mammoths were killed individually along the edge of the watering hole in an opportunistic style of hunting. Clovis campsites were located near the spring conduits of the watering hole, but evidence of mammoth consumption has been erased due to sheet-wash events (Boldurian and Cotter 1999; Hester 1972; Warnica 1966).

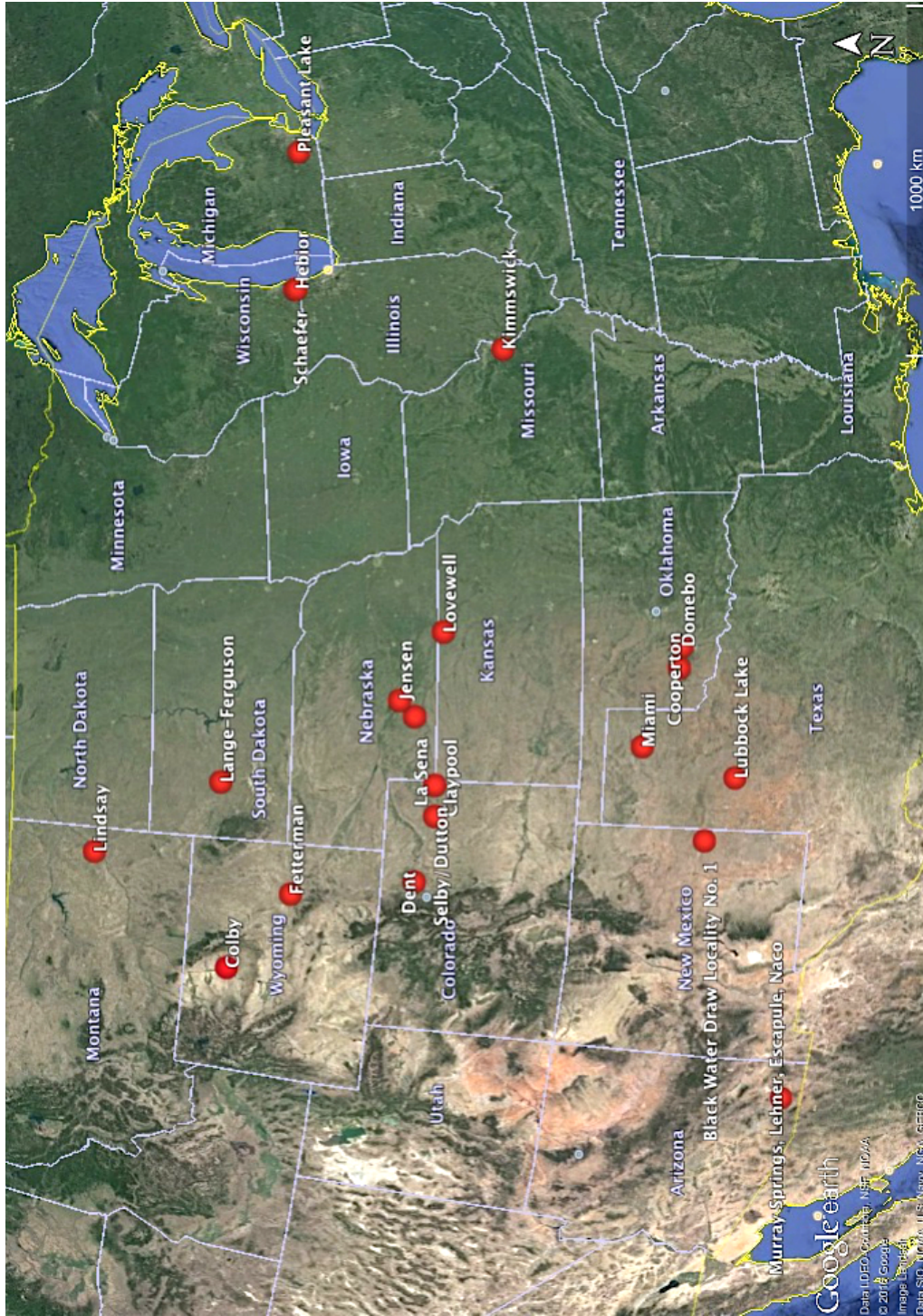


Figure 2.1 The Locations of Mammoth Archaeological Sites.

Table 2.1 Confirmed Clovis and Mammoth Association

Site	Location	Radiocarbon Date (Uncalibrated)	# of Animals
Black Water Draw (Clovis Type site) Locality No. 1	Roosevelt County, NM	11,170 ± 360 (A- 481) 11,040 ± 500 (A- 490) 11,630 ± 400 (A- 491)	5 Mammoths
Colby	Washakie County, WY	11,200 ± 220 (RL- 392) 10,864 ± 141 (SMU- 278)	6 Mammoths
Dent	Weld County, CO	11,200 ± 500 (I-622)	15 Mammoths
Domebo	Caddo County, OK	11,045 ± 647 (SM- 695)	1 Mammoth
Escapule	Cochise County, AZ	-	1 Mammoth
Hebior	Kenosha County, WI	12,590 ± 50 (AMS- 61137) 12,520 ± 50 (CAMS- 61136) 12,480 ± 60 (CAMS- 28303)	1 Mammoth
Kimmswick	Jefferson County, MO	-	2-5 Mastodons
Lange- Ferguson	Shannon County, SD	10,670 ± 300 yr B.P. (I-11,710)	2 Mammoths
Lehner	Cochise County, AZ	11,850 ± 50 yr B.P. (A- 40a and A-40b) 11,180 ± 140 yr B.P. (K-554) 11,290 ± 500 yr B.P. (M-811)	9 Mammoths
Lubbock Lake	Lubbock County, TX	11,100 ± 100 yr B.P. (SMU- 548)	3 Mammoths
Miami	Roberts County, TX	11,415 ± 125 yr B.P. (AA- 7086) to 10,345 ± 330 yr B.P. (AA- 7085) (Indirect Loess layer dating)	5 Mammoths
Murray Springs	Cochise County, AZ	11,230 ± 340 yr B.P. (A-805)	4 Mammoths
Naco	Cochise County, AZ	9250 ± 300 yr B.P. (A-9 and A-10)	1 Mammoth
Pleasant Lake	Washtenaw County, MI	10,395 ± 100 yr B.P. (BETA- 1388)	1 Mastodon

Black Water Draw (Haynes 1991; Hester 1972), Colby (Frison and Todd 1986), Dent (Agogino 1997; Brunswig 2007), Domebo (Albritton 1966), Hebior (Joyce 2005; Overstreet and Kolb 2003), Kimmswick (Graham et al. 1981; Lange-Ferguson (Hannus 1985), Lehner (Haury et al. 1959), Lubbock Lake (Holliday et al. 1983), Miami (Holliday et al. 1994), Murray Springs (Haynes 2007), Naco (Haury et al. 1959), Pleasant Lake (Fisher 1984)

2.1.2 *Colby*

Located in north central Wyoming, the Colby mammoth site yielded a total of six mammoths (*Mammuthus columbi*) separated into two bone piles along an ancient arroyo channel. Bone pile 1 contained two Clovis projectile points, a third was found in bone pile 2, and a fourth Clovis projectile point was discovered before excavations began. The lack of any cut marks was explained by modern experimental butchering conducted on an Indian elephant. The joint capsule of the front limb proved to be thick enough that tool blades were unable to reach the bone surface before disarticulation could be accomplished. The wide range of bone weathering found in the two bone piles indicates individual kills rather than a single kill event (Frison and Todd 1986). The unique discovery of several individual kill events in a single arroyo channel gives credence to the use of arroyos as an opportunistic hunting strategy.

2.1.3 *Dent*

Similar to the Colby site, the Dent site is located in north central Colorado in a stream channel and consists of ten juvenile mammoths of 16 years of age or younger and five mature adults of 22 years of age or older. Unlike Colby, however, the number of kill events was more likely two rather than 15 individual kill occurrences. Both primary and secondary butchering marks found on the bones suggest kill processing and scavenging took place at the site. It was initially proposed by Haynes (1966) that Dent represented a bluff kill where a small matriarchal herd was stampeded into the channel over the bluff edge and butchering was subsequently conducted on the specimens that were easily accessible. Brunswig (2007), however, concludes that the slope angle of the channel bluff was more likely to be gentle and the habits of a protective matriarchal herd would have encircled the young shielding them from predators rather than run in stampede fashion over the bluff. He suggests that the more likely scenario involved the small matriarchal herds being maneuvered up the channel and consequently ambushed. In either case, Clovis influence in the demise of these herds is apparent by the two complete Clovis projectile points and one reworked projectile point that were found among the bone piles during excavation (Brunswig 2007).

2.1.4 *Domebo*

The Domebo site is represented by a single mammoth found in an ancient arroyo channel located roughly west southwest of Oklahoma City, Oklahoma. Three projectile points were

found in association with the mammoth of which two were complete and determined to be Clovis with the third only representing a medial fragment and deemed unidentifiable. A fourth projectile point was added to the collection although the association is not definitive having being found downstream from the rest of the skeleton, but exhibiting morphological similarities to the other two complete projectile points. Cut marks and intentional bone fracturing were hard to determine due to the state of preservation of the bones. The discovery of projectile points found *in situ* within the bone bed suggests a positive correlation between the hunters and this specific mammoth, however, the lack of butchering modification could be attributed to thick joint capsules as was suggested by Frison and Todd (1986) at the Colby site (Leonhardy and Anderson 1966; Mehl 1966; Retallick 1966).

2.1.5 *Hebior*

Hebior is part of a cluster of mammoth sites (*Mammuthus primigenius*) which encompass the Hebior- Schaefer sites, Mud Lake site, and Fenske site located in southeastern Wisconsin. The uniqueness of these sites is that radiocarbon dating puts these sites at least a thousand years earlier than any other known mammoth kills on the continent (see Table 2.1). The Hebior site specifically represents one of two mammoths (85% -90% complete) found within the cluster of sites and exhibits evidence of cutmarks and prymarks. The only archaeological remains found at Hebior were two bifacial implements and a couple of flakes located in and around the bone pile. Butchering or scavenging of this mammoth was conducted near a proglacial pond or lake and subsequent inundation covered the bones in clastic and organic sediment (Johnson 2007; Overstreet and Kolb 2003).

2.1.6 *Kimmswick*

The Kimmswick site is located in east-central Missouri and represents a mastodon kill (*Mammut americanum*) in the eastern periphery of the Great Plains. Two Clovis projectile points were found in the upper pond deposit in direct contact with mastodon remains with additional Clovis artifacts found in a second pond deposit directly below the first. Stratigraphic analysis concluded that turbation was not prevalent in mixing mastodon bones with Clovis material and therefore they were excavated in primary deposition (Graham et al. 1981).

2.1.7 *Lange-Ferguson*

The Lange-Ferguson site is comprised of two mammoth kills (*Mammuthus jeffersoni*), one adult and the second juvenile, in southwestern South Dakota. Butchering of the mammoths, which was concentrated primarily in Butte A, was conducted using bone tools constructed from the scapula and long bones of the two mammoths after disarticulation took place. Butte A possessed a single lithic fragment located within the bone bed and Butte B contained three Clovis projectile points. Butte A was determined to be the main butchering area with Butte B designated for secondary butchering and tool fabrication (Hannus 1985, 1990).

2.1.8 *Lubbock Lake*

Lubbock Lake is a well-stratified late Quaternary site that has been extensively radiocarbon dated in west Texas south of the panhandle. A Clovis projectile was found in association with not only a juvenile mammoth (*Mammuthus columbi*), but also Pleistocene camel (*Camelops hesternus*), bison (*Bison antiquus*), a giant armadillo (*Chlamytherium septentrionale*), horses (*Equus sp.*), and a giant short face bear (*Arctodus simus*). Also found *in situ* were a pounding stone and anvil interpreted to be a processing area on a point bar near a meandering streambed. The bones presented cut marks, impact fractures, and some use-wear (Holliday et al. 1983; Kreutzer 1988).

2.1.9 *Miami*

The Miami site is located in the panhandle of Texas and contains five mammoths, three adults and two juveniles. They were deposited over a stratum of loess within an ancient watering hole that then filled in to become indistinguishable from the topographic landscape. Artifacts were found in definitive association with mammoth bones as they were discovered in horizontal position above the loess layer and with a carbonate concretion coating the underside, mimicking the depositional characteristics of the mammoth bones. Three Clovis projectile points were found in association with the rib and vertebral portion of an adult mammoth. The second projectile point was found in two pieces with the basal portion found near rib bones and the body portion recovered closer to the atlas. A side scraper was also collected during the initial excavation with an additional side scraper and two retouch flakes found during surface collection with bone fragments in 1990. Taphonomic studies were not conducted due to poor preservation of the bone (Holliday et al. 1994; Sellards 1938).

2.1.10 *Pleasant Lake*

The Pleasant Lake site is located in southeastern part of Michigan. This mastodon differs from the previous kills in that it does not contain any Clovis stone tool artifacts in association with the remains. It does, however, contain definitive proof of butchering evident on the bones. These are in the form of disarticulation marks that are prevalent on the atlas and axis articulation with individual markings on each bone mirroring the marks found on the adjacent articulation surface. Disarticulation marks are also found on the junction between the left femur and tibia. Cut marks are also predominant along with intentional bone fracturing and the use of bone as expedient tools. Burning is also prevalent on some of the bones indicating that the burning occurred after disarticulation, but prior to soft tissue being removed entirely. The lack of lithic material found at Pleasant Lake could be explained by a number of factors including excavation oversight and the tendency for stone tools in the Great Lakes area to be reused even after major breakages (Fisher 1984; Shipman et al. 1984).

2.1.11 *Naco, Murray Springs, Escapule and Lehner*

These sites are all within a 35-mile radius of each other and are situated in the San Pedro Valley system in the very southeastern corner of Arizona. It is likely that associated groups are responsible for the kill sites found in the valley (Grayson and Meltzer 2002; Haury et al. 1986). No occupation camp has been found, but several hunting camps and processing areas have been identified in association with these four mammoths. The Naco and Lehner sites show a multitude of similarities in geomorphological deposition and projectile point morphology. Haury et al. (1986) remark that the projectile assemblages of both sites yield little to no variation and could be combined to form a single unifying assemblage.

Naco

The Naco mammoth is a single mammoth kill found in association with eight Clovis projectile points in and around the bone bed. Determined to be *Mammuthus columbi* through molar radiometrics (Haury et al. 1953), the mammoth was first discovered in 1951 in an arroyo channel that may have eliminated some of the hindquarters leaving only the skull, fore limbs, and vertebra and ribs. The projectile points range in lengths due to reworking and are mostly made of dark grey cherts with the addition of a brown chert and red chert (Haury et al. 1953).

Murray Springs

Three areas containing a total of four mammoths represent the Murray Springs site. Arroyo cutting has disturbed the first two areas and thus no association to Clovis can be definitive although the presence of flakes in and around the bones may be contemporaneous. The partial remains of an adult cow, *Mammuthus columbi*, represents the third area. This mammoth was associated with a flake cutting tool and a cobble hammerstone (Hemmings 2007). Disarticulation was part of the butchering sequence with a hindlimb found near the skull, a radius and ulna found near the sacrum, and part of the forelimb still articulated but missing the lower half. The area surrounding the processing site was interpreted as a wallow due to the presence of mammoth and bison tracks near a depression. Due to the short distance between the watering hole and the position of the remains, it was interpreted that the site was used for scavenging carcasses given the lack of any weaponry found among the bones (Hemmings 2007).

Escapule

The Escapule site is home to a single immature *Mammuthus columbi*, which was found eroding out of the bank of the Horse-Thief Draw in 1966. Louis W. Escapule, the discoverer, minimally excavated the site and recovered two Clovis projectiles from among the ribs. However, further careful excavation did not reveal any more artifacts or evidence of butchering on the bones. This suggests that the animal may have been targeted during a hunt and eventually got away only to succumb to its wounds (Hemmings and Haynes 1969).

Lehner

The Lehner site represents the most extensive mammoth kill in the San Pedro Valley. After the first phase of excavation was complete, a total of eight mammoths represented the MNI and additional bone fragments of bison were found. Moreover, 13 projectile points near or touching the bones were found with the addition of eight cutting and scraping tools, a chopper, and several flakes. The deposition in a white sand layer suggests the kill took place on an ancient perennial stream channel that is located adjacent the modern arroyo cut (Haury et al. 1986). The excavated locations of the bones suggest that multiple kill events took place over a short period of time rather than a single kill event. A second phase of excavation revealed two hearths immediately to the west of the initial excavation and these produced the charcoal that was found in the adjacent bone bed. An additional mammoth jaw with accompanying horse metapodial and

a lower jaw of a tapir were also found in this area. Radiocarbon dates were obtained using the charcoal from these hearths after association was inferred to have been the cooking area associated with the kill sites to the east (Haury et al. 1986).

All of these sites were able to indisputably prove that Clovis and proboscidean association was present. However, these sites produced Clovis projectile points or stone tools in direct association with the bones and thus immediate association could be inferred.

2.2 Clovis Sites with Possible Mammoth Association

There are a number of sites with mammoth remains that are not well established with the Clovis technocomplex, but demonstrate possible evidence of bone modification through butchering techniques (see Figure 2.1). These sites, listed in Table 2.2 were discarded from Grayson and Meltzer's (2002) list of possible Clovis hunting sites due to a lack of data, archaeological context, or the only evidence present was the appearance of bone tools. Some of these sites, however, did meet the initial analysis requirements, but radiocarbon dates extending earlier than Clovis or Paleoindian times would have been out of the scope of the study and thus never included in the initial list. Nevertheless, it is worth observing possible patterns in butchering practices in order to further this thesis.

2.2.1 Claypool

Claypool is located in a modern blowout of a sand dune in northeastern Colorado. Two areas comprise the site with the first defined by the remains of a juvenile mammoth and the second distinctively associated with the Cody technocomplex. A chalcedony graver and Clovis projectile were found near the mammoth in Area I, but were determined not to be contemporaneous with the mammoth and possibly intrusive from an overlaying occupation. The mammoth was deposited in a marl bed which Malde (1960) determined to be of several hundred thousands of years old correlating to the Sappa Formation with dates in the early Yarmouthian range. For those reasons, the mammoth was disregarded as a possible Clovis megafauna butchering site (Dick and Mountain 1960; Malde 1960).

2.2.2 Cooperton

The adult Columbian mammoth that was found at the Cooperton site in southeastern Oklahoma in 1961 by Anderson (1962, 1975) has indications that marrow extraction may have occurred. Bones were found broken at the midshaft. In contrast, irregular and flat bones that

Table 2.2 Possible Clovis and Mammoth Association

Site	Location	Radiocarbon Date (Uncalibrated)	Stone tools	Pleistocene Megafauna
Claypool	Washington County, CO	No date from mammoth	Yes	Yes
Cooperton	Kiowa County, OK	17,575 ± 550 (GX- 1216)	Possibly	Yes
		19,100 ± 800 (GX- 1214)		
		20,400 ± 450 (GX- 1216)		
Fetterman	Converse County, WY	9060 ± 50 (CAMS- 72350) 8890 ± 60 (CAMS- 74661)	Yes	Yes
Lindsay	Dawson County, MT	9,490 ± 135 (I- 7028)	Possibly	Yes
		10,700 ± 290 (WSU-652)		
		10,980 ± 225 (I-9220)		
		11,925 ± 350 (-918)		
		11,500 ± 80 (B- 102031)		
		12,330 ± 50 (SR-5576)		
Schaefer	Kenosha County, WI	12,290 ± 60 (CAMS-72140)	Possibly	Yes
		12,310 ± 60 (CAMS- 30171)		
		12,320 ± 50 (CAMS- 61135)		
		12,390 ± 40 (CAMS- 61143)		
		12,440 ± 40 (CAMS- 72141)		
Selby/Dutton	Yuma County, CO	12,460 ± 45 (CAMS- 95516)	Yes	Yes
		7,880 ± 150 (SI- 3541)		
		11,710 ± 150 (SI- 2877)		
Jensen	Nebraska	13,600 ± 485 (SI- 5186)	No	Yes
		14,830 ± 220 (Tx- 8135)		
		18,000 ± 190 (Beta- 28728)		
La Sena	Frontier County, NE	18,444 ± 145 (AA- 6972)	No	Yes
Lovewell	Jewell County, KS	18,250 ± 90 (CAMS- 15636)	No	Yes

Claypool (Dick and Mountain 1960; Malde 1960), Cooperton (Anderson 1962; Collins et al. 2014), Fetterman (Byers 2002), Lindsay (Waters and Stafford 2014), Schaefer (Collins et al. 2014; Joyce 2006), Selby/Dutton (Collins et al. 2014, Holen and Holen 2011; Stanford and Graham 1985), Jensen (Collins et al. 2014; Holen and Holen 2011), La Sena (Collins et al. 2014; Holen 2006), Lovewell (Collins et al. 2014; Holen 2007)

are usually found broken due to natural processes were found to be intact, thus making the case stronger for intentional bone breaking due to the inconsistencies found in terms of natural breaking patterns. Also found at the site was a large cobble with battering present on one surface and small bone fragments located around this cobble. In addition, three fist-sized cobbles were found among the bones and due to the fine alluvial sediments present, were determined to be cultural. Anderson (1975) interpreted this to be a marrow extraction station or bone tool making with the fist-sized cobbles representing hammerstones and the larger cobble the anvil. The radiocarbon dates that come from Cooperton range from $17,575 \pm 550$ and $20,400 \pm 450$ putting it well out of the Clovis time frame. In addition, the lack of any Clovis material at the site has raised doubt for other interpreters in terms of human involvement (Anderson 1975).

2.2.3 *Fetterman*

The Fetterman site, located in eastern Wyoming, was investigated in the summer of 1986. This area revealed 43 identifiable bones with an additional molar all belonging to an immature mammoth. AMS radiocarbon dates came back very young for this specimen and may be caused by an unidentifiable contaminant in the sample. A total of 16 lithic artifacts were found, of which four was recorded *in situ* among the remains. These included two flakes, a retouched flake, and a possible hammerstone. No identifiable projectile points were found. The association of the stone tools with the mammoth remains are questioned. A scenario was proposed to suggest that the stone tools were deposited after the partial burial of the mammoth and analysis of depth provenience suggest this is so (Byers 2002).

2.2.4 *Lindsay*

The Lindsay mammoth site, located in eastern Montana, produced 15 cut marks on four separate elements of a mammoth. The marks were perpendicular to the long axis of the radius, rib, calcaneus, and long bone fragments and were thought to be the product of meat stripping using stone tools. No stone tools were found at the site. However, eight sandstone cobbles were found in association with the bones and are identified as manuports due to the presence of loess and no geological explanation for their appearance in the layer (Waters and Stafford 2014). Bone breakage patterns (i.e. bone notches and splinters) indicate that the cobbles may have been used to access the marrow. Disarticulation is also evident given three lines of evidence: (1) the femurs were found on top of a rib pile, (2) the mandible was found separated from the cranium, and (3)

cut marks were found on the calcaneus with correlating articulated foot (Waters and Stafford 2014). The evidence for human presence at the Lindsay site is unequivocal. The reason the site may have not made Grayson and Meltzer's (2002) list of confirmed mammoth kills is likely the lack of information provided at the time of their study. Even now with the information finally provided, radiocarbon dates put the animal in a pre-Clovis era and the lack of stone tools would provide doubt to some.

2.2.5 *Schaefer*

The Schaefer site is located only 1.7 km north of the Hebior mammoth site described earlier. The remains of a male *Mammuthus primigenius* were uncovered in 1992 and 1993 that constituted 75% of the complete skeleton. In total, 16 cut marks and wedge marks were found on ten elements and indicated the process of disarticulation with the bones being subsequently discarded in a pile. Trampling marks and carnivore gnawing were also present on the bones. However, a definitive human presence could be established on the basis of two lithic artifacts located below the innominate. Radiocarbon dates also put the mammoth in close proximity to the Clovis time frame but not within it (Joyce 2006; Overstreet 1998). Grayson and Meltzer (2002) argue that the deposition of the mammoth was more likely to be secondary and thus the lithic material found as well. The radiocarbon dates obtained were from wood that was transported to the locality and thus suspicion is raised about the original deposition of the mammoth. For those reasons they did not include the Schaefer site in their list of confirmed Mammoth-Clovis associations (Grayson and Meltzer 2002).

2.2.6 *Selby/Dutton*

Selby and Dutton are two sites in close proximity along the northeastern border of Colorado that demonstrate flaking on mammoth as well as large ungulate bones. The bones presented impact scars suggesting marrow extraction and bone tool production was the primary activity. Several lithic flakes were recovered during water screening but none were found *in situ* (Holen and Holen 2011; Stanford and Graham 1985).

2.2.7 *Jensen*

The lesser-known Jensen site is located in the Platte River Valley in south-central Nebraska and contains the remains of an old male mammoth. The only evidence presented on the mammoth of human intervention is impact scars and a bone flake. Only a couple of limb bones

exhibit bone breakage indicative of human modification. All other bones were found intact. The modifications found were interpreted to be opportunistic bone tool making by humans due to the lack of any lithic material (Holen and Holen 2011). Radiocarbon dates put the mammoth well beyond the Clovis time frame and so with the lack of stone tools and a date that is too old, Grayson and Meltzer (2002) omitted this site as a possibility for human intervention.

2.2.8 *La Sena*

The partial remains of a 50-year-old adult mammoth found along the Medicine Creek Reservoir in southeastern Nebraska represent the La Sena site. There was no evidence of hunting or butchering from stone tools, however, there was evidence on the bones of spiral fracturing, impact scars and flakes with negative bulb of percussion and hinge termination. In addition, the most unusual find at the site was a broken vertebra with the spinous process penetrating below the surface. This was interpreted to be an anvil station where bones were being quarried to produce preforms. This is supported by the large numbers of fragments that show signs of intentional bone breaking in the form of spiral fracturing and flaking and the broken surface of the vertebra was situated vertically (Holen 2006).

2.2.9 *Lovewell*

The Lovewell site contained three mammoths found over an area of 225 m² in north central Kansas. The first mammoth discovered in 1969 was of an adult *Mammuthus columbi*. Spiral fractures were noted on the bones as was the ‘stacked’ nature of deposition. However, geologists determined that the red sediment found with the remains was Loveland loess and dated to 100,000 years. Archaeologists left the site without collecting the bones. It was later realized that the red silt the mammoth was found in was actually Gilman Canyon Formation deposits that looks similar to Loveland Loess. Peoria loess, which dates to roughly 20,000 years BP was found in the 1991 field season. The first mammoth was then estimated to be roughly 20,000 years old (Holen 2007). The second mammoth that was excavated in 1991, 2002, and 2004 showed evidence of spiral fractures, bone flakes with associated bulbs of percussion and platforms, and negative flake scars. Although the mammoth was transported slightly down a gully from initial deposition, the energy was not strong enough to create the fracturing seen on these remains. Moreover, the fragments are not size-sorted in final deposition also indicating a low energy form of transportation. A third mammoth was recovered that is only represented by

the presence of molar plates which could not be dated but based on the presence of Peoria Formation was estimated to be the same age as mammoth II (Holen 2007).

2.3 Clovis in Saskatchewan

Clovis projectile points in Saskatchewan are not overly abundant and the majority represent surface finds from agricultural fields. In 1966, Kehoe published the distribution of five Clovis projectile points throughout Saskatchewan. These surface finds resembled the Clovis style found in New Mexico, the Dent site, and the Naco and Lehner sites. These variants show the classic lanceolate shape with a slight, V-shaped concave base. He also recognized a number of atypical fluted projectile points (Kehoe 1966). Although the majority of these would have been reworked, the slight basal concavity and the pronounced formation of ears on the basal corners still suggest Clovis although a variant of the classic morphology.

A master's study done by Hall (2009) identified a total of 21 projectile points that represent the Clovis style in addition to the five that Kehoe first identified. Made mostly from Knife River Flint sourced out of North Dakota, the majority (17) have been reworked along the lateral edges and one was reworked into a drill. This style was found to be concentrated to the southwest region of Saskatchewan with the exception of three others found in the parkland region of Saskatchewan along the North Saskatchewan River and in the east along the Saskatchewan-Manitoba border. The addition of ice frontal position locations in Saskatchewan, in conjunction with the localities of these 21 projectile points, suggests the trend for human occupation in Saskatchewan during this time period would be along major glacial lakes and spillways (Hall 2009).

Hall (2009) also addresses the Northwestern Fluted variant which Kehoe initially characterized as atypical. A total of 35 projectile points are known in the province to date. This variant is generally shorter and wider than the classic Clovis although reworking may be an explanation for the lack of length. Compared to the classic Clovis, this variant shows a marked decline in the use of Knife River Flint with a preference geared towards locally sourced raw material (Hall 2009). This projectile point style is concentrated to the western half of the province with a couple of exceptions in the east along the Saskatchewan-Manitoba border.

Hall concludes in his study that the presence of Clovis in Saskatchewan would have been at the latest between 12,000 and 11,500 BP. This was interpreted based on the most northerly located Clovis projectile point, found near Medstead, Saskatchewan and the ice frontal positions

described by Kehoe (1966). By 15,500 BP the Swift Current area would have been free of ice, followed by the Kindersley plains around 14,000 BP and the Battlefords area around 12,500 BP (Dyck 1983). In addition, the development of habitable landscapes with the addition of flora around 14,000 BP and the migration of fauna into the south Saskatchewan landscape would support the notion that even humans migrated north into Saskatchewan immediately following the retreat of the Laurentide Ice Sheet and were able to survive in the environment (Hall 2009).

Chapter 3

Biophysical Background

A biophysical description in regards to the Kyle mammoth is necessary to understand the life and death of the animal. In addition, the site formation of the Kyle mammoth can aid in the identification of taphonomic features present on the bones such as stages of weathering when correlated to the exposed surfaces of the bones and position of deposition. Moreover, the biophysical background will show that mammoths and humans were able to survive in a proglacial landscape after the retreat of the glacial ice from Saskatchewan indicating that human and mammoth interaction was possible in Saskatchewan.

3.1 Bedrock Geology

The majority of southern Saskatchewan bedrock is made up of Cretaceous shales and siltstones that were laid down in shallow seas. The primary material comprising these shales and siltstone include bentonite and montmorillonite creating a weak expansive base in which glacial erosion and thrusting could easily alter the topographic landscape (Klassen 1989). Under the region surrounding Kyle, these sediments make up what is known as the Bearpaw Formation (Acton et al. 1998)

The interior plains of Canada show a steady decline in an east to northeast direction beginning at 1200 m a.s.l. just east of the Rocky Mountains and ending at 250 m a.s.l. at the edge of the Precambrian shield in northeastern Saskatchewan and north central Manitoba. Two Prairie “steps” are demarcated by a steep drop in elevation over a small geographical area and three gradually sloping steppes define the eastward decline of the interior plains (Klassen 1989). Beginning in the west, the Alberta Plain, which is characterized by a rolling landscape with dispersed upland and badlands further to the south, drops down 100 m to the Saskatchewan Plain along the escarpment known as the Missouri Coteau. The Saskatchewan Plain is characterized by a thick glacial drift with areas of higher elevation and minimal evidence of preglacial valley relief. The Manitoba escarpment, which runs in a northwest to southeast fashion encompasses

the Riding Mountains, the Duck Mountains, and Porcupine Hills along the Manitoba and Saskatchewan border dividing the Saskatchewan Plain from the Manitoba Plain. It is characterized by a steep 300 m drop in elevation between the two plains. Lastly, the Manitoba Plain spans east all the way to the Precambrian Shield and is of very low relief with few preglacial valleys and upland areas (Klassen 1989; Yansa 2007).

The Missouri Coteau needs further reference since the Kyle site is located on this feature. Beginning in south central South Dakota, the Coteau spans 1300 km northwest through North Dakota and across west central Saskatchewan with an average width of 50 km. It is comprised of Paleocene sediments which survived erosional factors of the Tertiary period and which are overlain by thick layers of Quaternary glacial sediments (De Vries 1963; Kehew and Teller 1994; Yansa 1998, 2007). The Coteau is important in glacial history as exposure of the Coteau determined glacial drainage patterns and geomorphological deposition. The drainage at the peak of the Last Glacial Maximum and the beginning of glacial retreat was towards the South into the Missouri River drainage system with the Coteau covered by glacier. Upon further retreat of the glacier and exposure of the Coteau, drainage would have shifted in an east to northeastern direction, as the Coteau's steep elevation would now be of topographical influence and serve as a drainage divide. Drainage towards the glacier's ice front would have dammed meltwater forming glacial lakes and subsequently affecting the proglacial landscape and meltwater spillways (Kehew and Teller 1994).

3.2 Glacial Retreat

The retreat of the Laurentide Ice Sheet and the subsequent morphing of the proglacial landscape, created a very distinctive topography such that a timeline of the recession can be identified across Saskatchewan. Correlating radiocarbon dates can be used to make a timeline of ice frontal positions and proglacial landscapes including positions of lakes and spillways (refer to Appendix A for Canada wide deglaciation by Dyke et al. (2003)). Christiansen (1979) began work on creating a deglaciation sequence of Saskatchewan working from previous research by Edmunds (1962) in addition to aerial photography by Elson (1958) and Colton et al. (1961) in adjacent provinces and states. Glacial landforms were analyzed to determine ice frontal positions and included features such as ridged moraines, ice-thrust moraine, end moraines, ice-marginal channels and spillways, glacial lakes, and flutings. The chronological history of retreat of the Laurentide ice sheet across Saskatchewan was reconstructed into a number of phases.

These phases were initially interpreted by Christiansen (1979) and later modified by Klassen (1989). Dyke and co-authors (Dyke and Prest 1987; Dyke et al. 2002; 2004) are concerned more with large-scale deglaciation encompassing all continental margins of the glacier with correlating radiocarbon dates. Due to the narrow scope of this thesis and the lack of updated glacial retreat sequences in Saskatchewan, the earlier proposed phases defined by Klassen (1989) with reference to Christiansen's earlier phases will be discussed here as they pertain to the study area.

The furthest extent of the Laurentide Ice Sheet to the south on the Interior Plains reached well into Montana and radiocarbon dates place it at roughly $20,000 \pm 850$ BP (Clayton and Moran 1982; Klassen 1989). However, areas of high topographical relief in Saskatchewan, mainly in the Cypress Hills region, remained uncovered by the ice and are referred to as nunataks. Here is where Christiansen (1979) begins Phase 1 of deglaciation in Saskatchewan, although it is related to an advancement event rather than retreat based on the large end moraine found in northern Montana. Regardless, large amounts of meltwater from the Cypress Hill region made its way down the Frenchman Channel towards the Missouri River to the south.

Klassen (1989) begins by combining phase 1 and 2 of Christiansen's chronology into his first phase. This phase, which includes the landscape described above in Christiansen's phase 1, also includes the drainage of meltwater through the Swift Current Channel into the Frenchman Channel earlier in the phase and through the Pelletier Channel into Glacial Lake Kincaid and subsequently through the Big Muddy Spillway into the Missouri River. This phase is also demarcated by the formation of the Thomson Moraine to the north of Etzikom Coulee (Christiansen 1979; Klassen 1989). This phase is dated to roughly 14 ka BP and is interspersed with advancement episodes (Clayton and Moran 1982; Klassen 1989).

Klassen's phase 2 is similar to Christiansen's phase 3 and only differs in Alberta and Manitoba. In Saskatchewan, the two phases are identical and describe the ice margin located at the sites of Fox Valley, Leinan, The Dirt Hills, and The Stoughton moraines. Meltwater drainage still flowed eastward through the Chin Coulee into Lake Bigstick, which was located between the Cypress Hills and the glacier front. Subsequently, meltwater then drained into Glacial Old Wives Lake via the Neidpath Spillway, and then successively south through the Big Muddy Spillway into the Missouri River. The date for this phase is roughly 13 ka BP, however, Clayton and Moran (1982) discuss a date of 11.7 ka BP for the phase they relate to this landscape (Klassen 1989).

Phase 3 is slightly modified from Christiansen's phase 4. Meltwater drainage in Saskatchewan, although still traveling east, does not drain south into the Missouri River, but rather into the beginnings of Lake Agassiz in Manitoba and North Dakota. This is due to the emergence of the Missouri Coteau and its influence on northeastward drainage. Lake Unity in western Saskatchewan drained via the Trampling Spillway into the early Lake Saskatchewan with the addition of the Whitebear Spillway from the South Saskatchewan River. Lake Saskatchewan and Lake Regina drained into Lake Agassiz, first via the Souris Valley Spillway, and then through the Qu'Appelle Channel once the glacier retreated from the Condie and Qu'Appelle Moraines. Radiocarbon dates from the Assiniboine and Qu'Appelle valleys date this phase at roughly 12 ka BP, although dates from South Dakota once again differ from this region (Clayton and Moran 1982; Klassen 1989).

Phases 5, 6, and 7 of Christiansen's chronology were merged by Klassen (1989) in a time period that ranges from 12 ka BP to 11 ka BP, although no assigned phase is given to these events. Within this time frame the glacier began to retreat rapidly beginning with ice marginal lakes draining completely out of Alberta followed by the drainage of lake Saskatchewan and Regina. Glacial Lakes Last Mountain, Saltcoats, and Melfort were formed and rapidly drained into Lake Agassiz (Christiansen 1978; Klassen 1989).

By phase 4 of Klassen's chronology (1989), Christiansen's phase 8 chronology corresponds with Klassen's in both age and ice frontal positions. The Saskatchewan River then formed a delta in the northern portion of Lake Agassiz with the North and South Saskatchewan rivers in roughly the positions found today. The western periphery of Lake Agassiz is bounded by the Manitoba Escarpment and follows the topographic relief along the Manitoba border to the north. In northwestern Saskatchewan, Glacial Meadow Lake drains via the Clearwater Spillway northwest into Alberta into Lake Peace. The Beaver River Moraine on the eastern portion of the lake is associated with the ice frontal position around 11 ka BP. Subsequent drainage of Lake Agassiz east into Lake Superior basin promoted incision of the North and South Saskatchewan rivers and Assiniboine River upstream (Christiansen 1978; Klassen 1989). The sequence of deglaciation is shown in Figure 3.1.

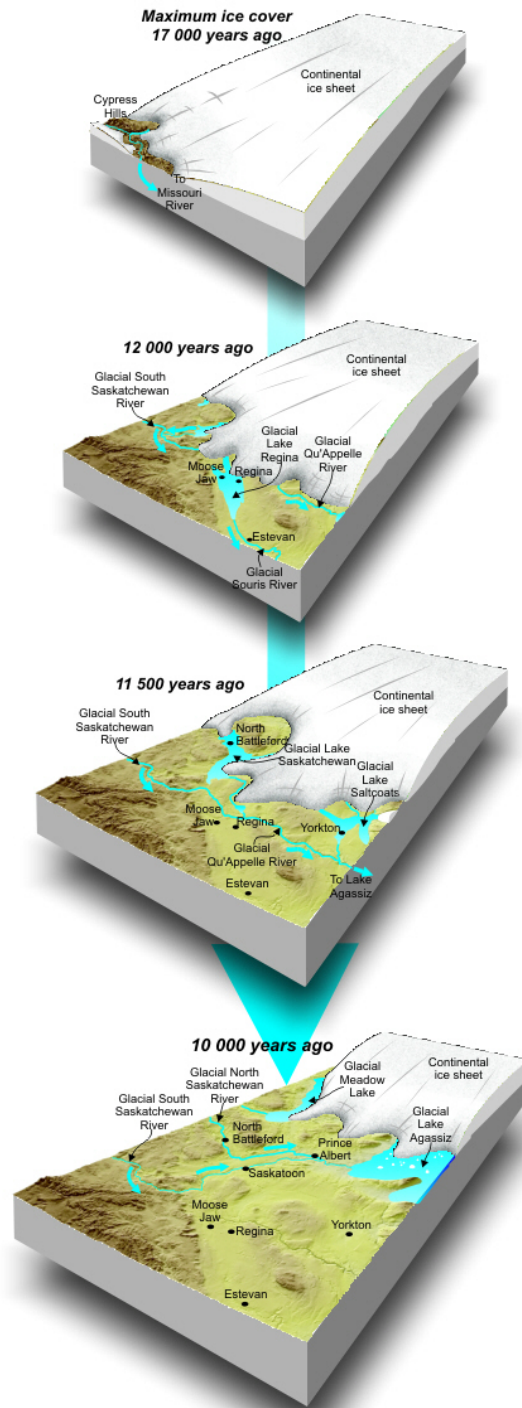


Figure 3.1 Ice frontal positions simplified by Turner et al. (2004) in Saskatchewan

Phase 5 dates to 10 ka BP with the ice margin located along the Cree Moraine on the Precambrian Shield. The Marquette ice advanced on the eastern end of Lake Superior caused a cessation of drainage into the Lake Superior Basin and consequently enlarged Lake Agassiz to its furthest extent. Primary drainage was to the south, but there is debate over a northwest route of drainage through the Clearwater Channel (Klassen 1989). Catastrophic discharge of Lake Agassiz took place to the east once the Marquette retreat began. The maximum extent of Glacial Lake Agassiz is dated to roughly 9.5 ka BP (Klassen 1989).

Phase 6 of Klassen's chronology deals with remnant Lake Agassiz and glacier frontal positions nearer to the Tyrrell Sea in the northeast (also known as Hudson's Bay) (Klassen 1989). In Saskatchewan, Christiansen (1979) ends his chronology at phase 9 which correlates with the furthest extent of Lake Agassiz. In terms of the scope of this thesis, further discussion on the retreat of the Laurentide Ice Sheet towards the north is excessive and only a general overview of Saskatchewan glacial history is provided.

3.3 Proglacial Landscape

In the area of Kyle in southwestern Saskatchewan, a more descriptive sequence of glacial retreat and the related proglacial landscape is needed. The phase which best represents the ice margin in close proximity to the site and the formation of a dynamic proglacial landscape is described by Kehew and Teller (1994) during the Qu'Appelle- Assiniboine Drainage Phase with a date of 11 ka BP. During this time, drainage east into Lake Agassiz was established through Lake Regina then into the Souris spillway into Lake Agassiz. Further retreat of the glacier opened up a lower spillway via the Qu'Appelle- Assiniboine network to the north that bypassed Lake Regina and amalgamated the South Saskatchewan Spillway with the Agassiz Basin. This amalgamation was established after the complete drainage of Lake Regina (Kehew and Teller 1994).

The South Saskatchewan River system to the west of the Qu'Appelle and Assiniboine drainage is very dynamic. Many smaller lakes surrounding the areas of Rosetown and Swift Current, formed abruptly and disappeared just as fast due to the formation of new drainage systems and overflow outbursts (Kehew and Teller 1994). Prior to the establishment of the upper Qu'Appelle drainage system near Elbow, glacial meltwater from both the Cordilleran Ice Sheet in the Rocky Mountains and meltwater from the Laurentide Ice front drained via the South Saskatchewan Spillway only to be obstructed by the continental ice sheet in the areas of

Rosetown and Elbow. Meltwater from the South Saskatchewan drainage system inundated the landscape forming Lake Rosetown, Lake Beechy/Birsay by Elbow, and Lake Stewart Valley along the South Saskatchewan Spillway near Kyle. Drainage of this area would first be directed through the Thunder Spillway in the upper portion of the South Saskatchewan River. Further retreat of the glacier front would have opened up the headwaters of the Qu'Appelle Spillway, draining Lake Rosetown via the Anerley Channel, Lake Elbow, and Lake Stewart Valley via the South Saskatchewan Spillway (Christiansen 1959; Kehew and Teller 1994; Scott 1971).

Around roughly 10.7 ka BP, all meltwater from western Saskatchewan was directed through the South Saskatchewan River valley to Lake Agassiz in the north instead of east through the Qu'Appelle Spillway. This is congruent with Klassen's phase 4 of deglaciation chronology (Kehew and Teller 1994; Klassen 1989).

Further detailed description is necessary to understand the intricate geomorphological landscape that surrounds Kyle. Although some reference has been made to proglacial lakes in the vicinity (within 100 km of the site), landforms within a stone's throw from the site also need more in-depth description.

Clearwater Lake is located 12 km northeast of Kyle, Saskatchewan and is surrounded by ridged end moraines and hummocky moraines with a kame complex landscape. The Clearwater Lake Moraine is a series of sub-parallel ridges spanning 24.14 km in a northwest and southeast direction with superseding swales. These ridges delineate fluctuating positions of the ice front in the area during the last deglaciation and are confined to regions underlain by the Eastend Formation. Ridge height ranges from 3 to 30 m above the preceding swale with the establishment of small lakes within the swales. Ridge composition contains primarily till with smaller amounts of gravel and sand and has largely remained unaltered since initial deposition with exclusion in the northern region being modified by gully formation (Christiansen 1959).

A kame complex, in association with the Clearwater Lake Moraines, is interpreted to be deposits from ice contact stratified drift that equates to the deposition of ridged end moraines. This complex is similar to a hummocky landscape with relief ranging from 3 to 30 m in elevation, similar to the adjacent ridged end moraines. The area delineated by the kame complex is dotted with kames, rimmed kettles, knobs, and small eskers. The general composition of the sediments in the kame complex is sand and gravel with hummocks dotting the landscape comprising of knobs of till (Christiansen 1959).

The Lake Stewart Valley Basin is situated on a terrace above the modern South Saskatchewan River valley. Lake levels, which were determined by outlet contours, were estimated at 730 m a.s.l. The lake basin, which overlays glacial till, is gently undulating and slopes towards the South Saskatchewan River valley. Topographical relief rarely exceeds 3 m and sediment composition of the lake basin contains silt and clay with areas of varve deposition (Christiansen 1959). This basin is where the Kyle mammoth was found.

3.4 Trench Profile Summary

In mid-November, 2015 a trenching project took place in the approximate location of the mammoth discovery. The project was not intended for the discovery of unearthed mammoth remains, but to obtain a clearer, undisturbed sedimentary profile and sediment samples for further analysis and description. In the course of a morning, a trench was excavated that spanned 5 m from east to west and descended to a depth of roughly 2.5 m. From the southern wall, a 3 m profile was drawn and 14 sediment samples were obtained at random locations throughout the profile for pollen analysis which will be presented in a separate publication. The horizon descriptions are given below followed by an interpretation.

3.4.1 Plough

The plough horizon is defined by the presence of decomposing organic material in a mineral fraction comprising of silt and clay. Organic material in the process of decomposition is prevalent in Figure 3.2, but does not dominate over the mineral fraction. The lower boundary has clear (c) distinctness and a smooth topography (s), which is evident in Figure 3.3. The structure grade of this sediment is weak (1) and granular (Birkeland 1999). A Munsell reading of Olive Brown (2.5Y 4/3) was given.

3.4.2 Silty Clay

The silty clay horizon that lies directly below the plough zone is comprised mainly of clay with a small mixture of silt. The structure grade of this horizon is also weak (1) and granular with a boundary that is abrupt and a topography that is wavy (w) in the eastern portion and irregular (vi) on the western half of the profile. The horizon becomes ‘pinched-out’ for a few cm in the western part by the underlying horizon impeding towards the overlying plough zone. The horizon is brought back for the last few centimeters in the west. This horizon was given a Munsell reading of Dark Greyish Brown (2.5Y 4/2).

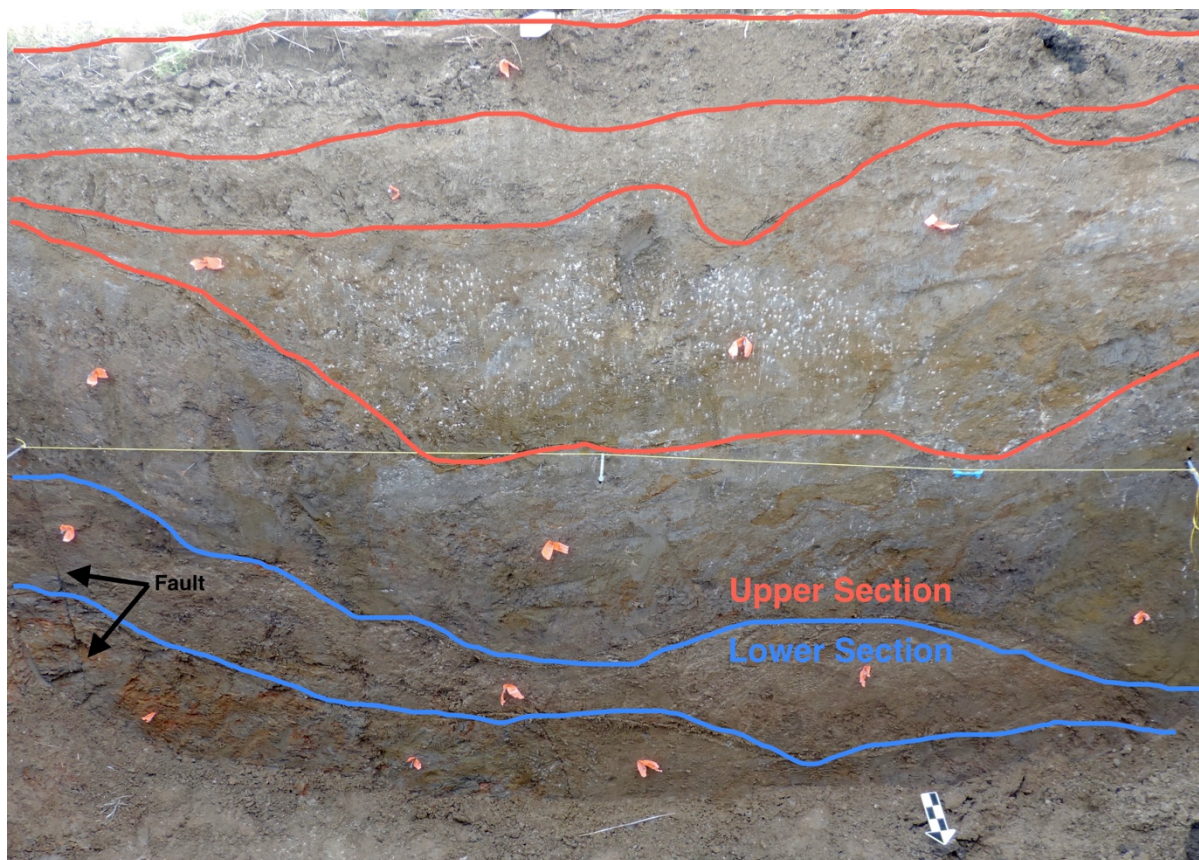


Figure 3.2 *Sediment profile in Kyle Saskatchewan depicting the six sediment layers described.*

3.4.3 Carbonate Clay

The carbonate clay horizon is very prominent as is evident in Figure 3.2 by the presence of CaCO_3 . It was given a Munsell reading of Grey (2.5Y 5/1). The boundary distinctness is abrupt (a) with a topography that is irregular (vi) in the eastern half and wavy (slw) in the west. The structure grade is massive (m) and carbonate morphology is in stage II. Attention needs to be drawn to the eastern half of this horizon as the layer ‘pinches out’ by the underlying horizon.

3.4.4 Iron Stain I

The Iron I horizon is defined by the iron deposition prevalent in the matrix. It was given a Munsell reading of Dark Greyish Brown (2.5Y 4/2) with the iron stains designated as Light Olive Brown (2.5Y 5/6). The boundary distinctness is abrupt (a) and the topography irregular (vi) while the structure grade is massive (m). The horizon slopes down from east to west on the western half of the profile.

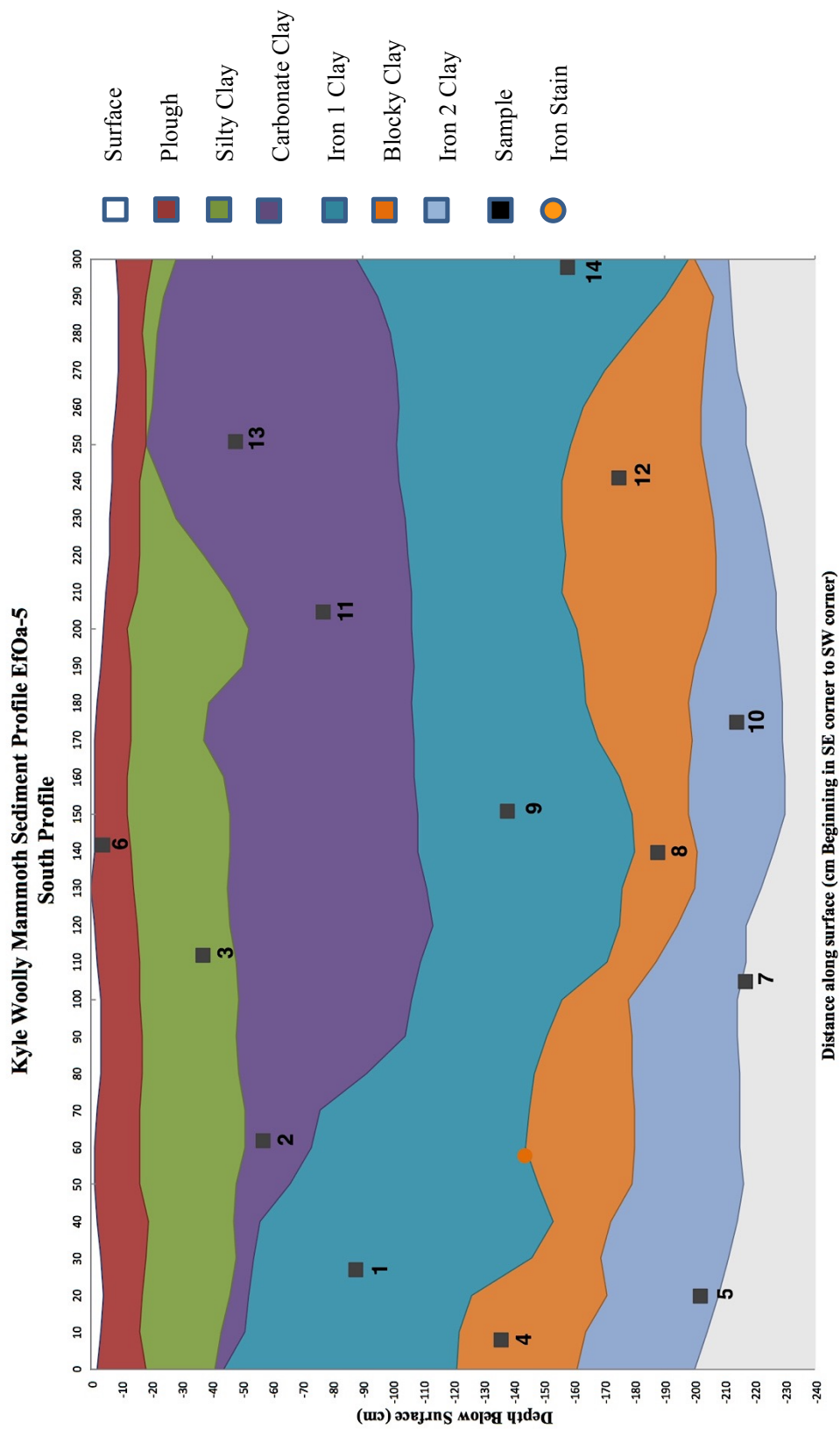


Figure 3.3 Kyle sediment profile simplified.

3.4.5 *Blocky Clay*

The Blocky Clay horizon is sloped downward from east to west and ‘pinches out’ at the western edge. The texture is a fine clay loam that becomes coarser further west in the profile. The structure grade is moderate (2) with a subangular blocky ped and the boundary distinctness is clear (c) with a wavy (w) topography. There is vertical fracturing that is apparent on the eastern aspect of the profile. This horizon was given a Munsell reading of Dark Brown (10YR 3/3).

3.4.6 *Iron Stain II*

The last horizon, which was not fully exposed, is defined by a Munsell reading of Dark Grey (2.5Y 4/1) with red iron staining of Red (10R 4/8). The structure grade is moderate (2) and has a predominant clay texture. The fracturing that were seen in the overlying sediment are extended into this horizon as well and deeper still. Unfortunately, not much else can be said about this horizon due to the lack of exposure of the lower boundary.

The sediment deposition can be distinctly separated into two sections as they represent two separate events deposition; the upper and lower sections. The upper section includes the Plough, Silty Clay, Carbonate Clay, and Iron Stain I horizons while the lower section is represented by the Blocky Clay and Iron Stain II horizons.

3.4.7 *Upper Section*

The upper section is interpreted to be the deposition of glaciolacustrine clays by Glacial Lake Stewart Valley followed by a single pedogenic event forming soils. The massive amounts of clay deposits that are prevalent in this section would indicate the settling of fine grained sediment out of suspension within the body of the lake during its existence. Lake floor sediments usually deposit in horizontal layers, however, the action of gravity flows become prevalent when slopes are present on the margins of lakes or on lakebeds (Bennett and Glasser 2009). The pinching of sediments that are present in the profile taken from Kyle would suggest that gravity flows took place during the deposition of sediments in Glacial Lake Stewart Valley to form massive deposits that are roughly horizontal in the upper section. Subsequent pedogenesis took place to form the soils after the retreat of Glacial Lake Stewart Valley that are seen in this section of the profile. The Saskatchewan Soil Survey (1994) designated the soils in this area of the study as Willows Soils and more specifically Orthic Willows. These soils are described as a dark

grayish-brown A horizon with a grayish-brown B horizon and a moderately calcareous C horizon. They occur on the upper slopes of gentle Willows landscapes and are well drained.

The two horizons that are titled Iron Stain I and Iron Stain II both indicate the presence of a high water table. This is indicated by the oxidization reaction that is occurring in the horizon which leaves a distinct mottled iron soil. This is also indicative of a well-drained sediment profile given that a mottled soil is first subjected to a reducing state in which the soil is well saturated, followed by an oxidizing state in which the sediment is then dried leaving the iron staining on a seasonal basis. This shows that the sediments in this area are not permanently saturated all year round (Birkeland 1999).

3.4.8 Lower Section

The lower horizons are interpreted to be buried sediments related to hummocky kettle fills. The deduction is due to the drastic change in texture from clay to an observable increase in silt within the clay between the Iron I horizon above and the Blocky Clay horizon below. The addition of fractional features apparent on the eastern portion of the two horizons that does not extend into the overlying horizons also indicates a separation in deposition sequence. McDonald and Shilts (1975) observed in the Oak Ridges Moraine the presence of high-angle reverse faults, or extension fractures (Bennett and Glasser 2009), that were caused by the melting of a very large block of stagnant ice within the moraine material that deformed the overlaying sediments and created the faults. Although the faults observed in the Kyle profile are very minute in comparison to the ones observed by McDonald and Shilts, they show similarities that would suggest the same process occurred in these sediments but on a smaller scale (Bennett and Glasser 2009, McDonald and Shilts 1975). In addition, the angle of deposition of this horizon would suggest the underlying parent material has a topography that is highly undulating or catena in nature (Birkeland 1999) which is characteristic of a hummocky landscape.

Assuming the interpretation of the above profile is accurate, then this deposition sequence would be indicative of a hummocky landscape overlain by glaciolacustrine clays. This would also indicate that the horizons in which the mammoth remains correlate to are suggestive of a hummocky landscape underlain by stagnant ice and overlain by glaciolacustrine sediments. The mammoth remains were found in a sandy deposit, which Dr. E. Christiansen suggested was in a kettle depression, and subsequent inundation of Glacial Lake Stewart Valley deposited large amounts of clay sediments on top of the remains. Based on the profile taken from the area

immediately surrounding the original location of the remains, Dr. E. Christiansen's initial assessment could be corroborated.

3.5 Biophysical Background

The Kyle mammoth site lies in the ecoregion of Saskatchewan known as the mixed grasslands. Flat undulating plains defined by glaciofluvial, glaciolacustrine, and glacial till dominate the physiography while deeply incised valleys and hummocky uplands dot the landscape. The climate is warm with an average annual temperature of 4° C and a daily mean range of 18.9° C during July and -12.6° C in January. Annual precipitation has a mean of 352 mm with the majority (219 mm) falling between the months of May to September (Acton et al. 1998). The relationship between the warm moist air from the Gulf of Mexico, the cold dry air from the Arctic and warm flow from the Pacific all help to define this ecoregion. The Gulf air dominates during the spring and summer while the Pacific and Arctic air masses compete during the winter months. Droughts are caused by a dominant Pacific air mass, which travels over the Rocky Mountains releasing moisture and becoming a dry air mass by the time it reaches the eastern edge of the Rockies creating what is known as a rain shadow. The air mass subsequently pushes the moist Gulf air eastward creating a drought east of the Rocky Mountains (Bryson 1980).

The vegetation that dominates this ecoregion includes blue grama grass, wheatgrass, and speargrass. Woodland is absent in this region. June and sedge grasses are also apparent and dominate landscapes underlain by lacustrine clays. Shrublands do appear in depressions with a sandy soil matrix. The most abundant plant is pasture sage. Coulees are dominated by willows, choke cherry, Saskatoon berries, and snow berries. Where intensive grazing has occurred, the vegetation is predominantly short- grass with mid- grasses having been destroyed. Wetlands that dot the landscape shelter plants such as sedges and rushes (Acton et al. 1998).

Fifty-one mammal species, a handful of fish and reptiles, and roughly 200 bird species dominate fauna in this ecoregion. Some of the mammal species that inhabit this ecoregion include: white-tailed jack rabbit, voles, five species of mice, masked shrew, thirteen-lined ground squirrel, northern pocket gopher, Richardson's ground squirrel, porcupine, striped skunk, least weasel, red fox, coyotes, pronghorn, mule and white-tailed deer. Of the almost two hundred bird species reported in the area, only fifteen breed in the ecoregion and include, short-eared owl, northern harrier, burrowing owls, sandpiper, marbled godwit, long-billed curlew, sharp-tailed

grouse and some passerines. Fish in the area constitute thirty-six species that include walleye, northern pike, yellow perch, and burbot with goldeye, sauger and lake sturgeon found in the South Saskatchewan River (Acton et al. 1998).

The modern ecoregion from this area, although useful when observing the landscape today, does not relate in any sense to the landscape that would have been present at the time of the mammoths. A look at paleoecological studies of the area is needed in order to better understand the climate and landscape that would have been present 12,000 years ago.

3.6 Paleocology

The paleoecology of the interior plains during the Late Quaternary is sparse in terms of environmental information. Preglacial deposits give the most reliable information obtainable and records from the more northerly United States not covered by continental glaciers. Of the information that is obtainable, a general trend in the decline of flora and fauna diversity is apparent from the beginning of the Quaternary up until contact times. The continental glacier essentially eradicated many species as it advanced south and making it difficult for the same amount of diversity to be able to re-establish northward in the interior plains after retreat (Klassen 1989).

3.6.1 Flora

Palynology studies of prairie pothole regions in southern Saskatchewan help to recreate the paleoenvironment in terms of vegetation. Yansa (2005) did multiple studies of this region that also extends into North and South Dakota. Lake core studies help to identify Holocene paleovegetation, paleoclimate, and paleohydrology by looking at pollen, ostracode, diatom, and geochemical make up. However informative, the issue with studying lake cores on the northern prairies is the lack of information dating further back than roughly 6 ka BP. Only a few lake cores dating to 12 ka BP exist. Thus, kettle ponds, or potholes, found on hummocky landscapes provide plant macrofossils that aid in recreating terminal Pleistocene transitioning to the early Holocene paleoenvironments (Yansa 1998).

From the Andrews site, which is located in south central Saskatchewan in the prairie pothole region that extends northwest towards Kyle, Yansa (1998) was able to extract a number of plant remains from Zone II or a kettle pond that inferred a pond development phase in the landscape roughly 10.2 ka BP. The dominant species found *in situ* was that of *Picea glauca*

(White Spruce) indicating that a Spruce forest would have been dominant on the till overlaying stagnant ice. Subsequent melting of the underlying ice collapsed the sediment and spruce trees lining the edge of the kettle pond would have been deposited in it. In addition, *Drepanocladus polycarpus* was found in two three-centimeter layers near the base of Zone II. This moss species is indicative of a carbonate- rich water environment in association with submerged plants and wet meadow shoreline plants. Thus this phase is suggestive of the beginning of pond or wetland development (Yansa 1998). Plant remains from the Andrew site that represents submerged and floating taxa, such as *Hippuris vulgaris*, *Lemna trisulca*, *Myriophyllum vericillatum*, and *Potamogeton filiformis*, suggest the water present was slightly alkaline to slightly brackish. The flora remains found that are indicative of wet meadow vegetation (i.e. *Mentha arvensis*, *Chenopodium berlandieri*, and *Aster novae-angliae*) suggest that the water was more likely to be slightly alkaline. In addition, submerged plant taxa that were present indicate a permanent deep-water pond that was at least two meters in depth (Yansa 1998).

Zone III at the Andrew site dates from 10.2 ka BP to roughly 8.8 ka BP and consists of lacustrine sediments. *Picea glauca* disappears almost entirely and is replaced by *Betula*, *Betula occidentalis*, *Populus balsamifera*, and *Populus tremuloides* that suggest a warming climate. *Picea glauca* thrives in climates that are below 17° C (Ritchie and Harrison 1993). With the disappearance of *Picea* it can be inferred that the mean annual temperature of the region increased to above 17° C between 10.2 ka BP and 8.8 ka BP. In addition, *Populus tremuloides* is drought-tolerant, which also suggests a warming trend from Zone II to Zone III at the Andrew site (Yansa 1998). The alkaline water was also becoming more brackish as was indicated by the disappearance of sensitive aquatic plants and the appearance more tolerant aquatic plant species. The pond also began to shallow towards 8.8 ka BP as is indicated by the presence of *Typha latifolia*, *Chenopodium salinum*, and *Rumex maritimus* that grow in fluctuating water levels at the Andrew site (Yansa 1998). Therefore, during the formation of lakes and ponds on top of till overlaying stagnant ice, spruce forests with shrubs and small plants would have dominated the proglacial landscape. The subsequent transition into the Holocene indicates a warming climate environment that is accompanied by the replacement of spruce forest with deciduous hardwoods and a general drying trend towards 8.8 ka BP (Yansa 1998, 2006). Although the Andrew site is not in the same region as Kyle, it is inferred that paleoenvironments of the two regions would have been very comparable given the topographic similarities.

In a separate publication, Yansa (2006) was able to identify spruce macrofossils from a site near Kyle, Saskatchewan on the Missouri Coteau. The tree stump that was found was dated to $10,300 \pm 90$ ^{14}C yr BP (12,100 cal yr BP) indicating that *Picea spp* was in the area in the terminal Pleistocene and persisted until 9980 ^{14}C yr BP (11,500 cal yr BP) (Date from Clearwater Lake site, Yansa 2006). Unlike the cold tundra ecoregions that we see today in the northern territories, the ice front would have been composed of spruce trees with deciduous shrubs and herbs (Yansa 2006). The term ‘forest’ does not imply, in this case, densely packed vegetation spanning across the landscape, but rather it is suggested that the spruce forest is instead spruce parkland that dominated the paleolandscape after the retreat of the glacier in addition to *Artemisia*, *Ambrosia*-type, *Poacea*, and *Cyperaceae* vegetation. The excavation of kettle ponds at the Andrew, Kyle, and Beechy sites supported this interpretation of open spruce parkland. These sites only produced 3- 5 white spruce logs, which suggest that only a couple trees were established on the shorelines of these ponds. In addition, the lack of a buried organic horizon (paleosol) in the developing soils would also suggest a lack of a ‘forest’ density (Yansa 2006).

The pollen analysis, which will accompany this publication in a separate publication, will supplement these earlier findings and give an even closer look at paleovegetation in association with the Kyle Mammoth.

3.6.2 Fauna

Quaternary fauna provides the most information in terms of paleoenvironmental data with correlating dates. The rich diversity of fauna was subsequently lessened due to an extinction event that took place at the end of the last glaciation. This event eradicated many of the larger fauna that were prevalent at the end of the Last Glacial Maximum. Proboscideans, horses, camels, ground-sloths, lions, saber-toothed cats, and dire wolves are some of the more prominent species to have died out during this time. However, smaller mammals such as the fox, coyote, skunk, and ferrets remained in abundance into modern times (Klassen 1989). Klassen (1989) published an extensive list of fauna that would have been prevalent during the late Quaternary, which will help supplement the reader’s knowledge in this area.

This extinction event is heavily debated especially as to whether or not it was caused by human overkill (Agenbroad 2005; Grayson and Meltzer 2002; Haynes 1991; Waguespack 2007, 2014). Haynes (1991) alternatively suggests that climatic factors were the ultimate cause for extinction of proboscideans in the New World. He outlines three factors that contributed to the

positive feedback loop that lead to the demise of, not only the proboscidean, but other Late Quaternary species as well. First, the depletion of watering holes due to an increase in aridity and temperature would have created an overcrowding effect that caused severe dehydration and the exhaustion of vegetation surrounding watering holes. Competition would subsequently intensify leading to injury and an increase in subadult mortality as well as increased susceptibility to predation, disease, and accidental death (Haynes 1991). Therefore, the human factor in the demise of proboscideans would have been evident in terms of opportunistic predation, which would only serve to exacerbate the situation, but does not indicate overkill extinction by humans.

The distribution of mammoths covers an area of roughly 33,301,000 km² that includes both North America and Eurasia and is known as the Mammoth Steppe (Agenbroad 2005; Holen and Holen 2014; Kahlke 2015). In North America, the Mammoth Steppe ranges from northern Mexico and extends northward through the Great Plains region, into the Yukon, and Alaska and over the Bering Landbridge. This vast grassland was home to a rich diversity of mammals which included mammoth, camel, bison, horse, and llama with the accompanying predators including white lion, saber-tooth cat, dire wolf, and giant short-faced bear (Holen and Holen 2014). Biogeographic barriers limit the distribution of mammoths and include continental glaciers, mountain ranges with impassable valleys, marine shorelines, deserts, and environmental vegetation (Kahlke 2015). The greatest extent of *Mammuthus* was dated to 10-15 ka BP. Although this could be largely due to an increase in radiocarbon dating due to the potential association with Paleoindians, this time frame shows a vast dispersion in continental North America with the exception of the northern prairie regions (boreal), eastern territories (tundra), Quebec, and the Maritimes in Canada and the Mississippi lower basin area in the southern United States. A sudden decline in dispersion signifies the onset of extinction with only a handful of mammoths dating to less than 10 ka BP and located in areas of refugia in the southern prairies provinces, Wisconsin, and Michigan (Agenbroad 2005).

Mammuthus primigenius, a much smaller version of woolly mammoth, was thought to have come into North America via a second migration wave from Asia just before the peak of the Last Glacial Maximum and the coalescing of the Laurentide and Cordillerian ice masses (Guthrie 1990; Haynes 1991). This species dominated the more northern region of the continent and was usually associated with regions closer to continental ice frontal positions feeding on the grasslands of the Mammoth Steppe that consisted of sage and grass (Haynes 1991).

3.7 Summary

The portion of the Mammoth Steppe that would have been present at the time of the Kyle mammoth is characterized by the occurrence of White Spruce parkland with associated grassland shrubs and herbs overlaying dynamic hummocky moraine on stagnant ice. Other megafauna species and smaller mammals would have accompanied the presence of the Kyle mammoth on this landscape. The climate would have been colder and moister, yet trending towards a drier arid environment that would have greatly influenced the demise of the *Mammuthus* species. Around the time of the death of the Kyle mammoth, the remains would have been deposited in a kettle pond in which stagnant ice melt would have deformed pond sediments and displaced the remains within the pond sediments (Pettipas 1975). Subsequent inundation of the land and the deposition of large amounts of glaciolacustrine sediments would have covered the remains for preservation. After Glacial Lake Stewart drained, a landscape similar to what is seen today would be present around Kyle with undulating plains, and hummocky moraines visible in the distant east.

Chapter 4

Osteological Analysis

The osteological analysis conducted on the Kyle mammoth revealed three important features about the animal's biology. The first is the age at death of the specimen. The second is the sex of the animal and the third is the species to which this particular animal belongs. Moreover, the osteological analysis will confirm that these remains represent an individual animal and identify fragments that were previously unidentified.

In total, 62 elements were identified which included sesamoid bones and phalanges. Of the total assemblage, 56 were complete or almost complete bones and 6 were identifiable fragments of long bones, vertebra, or ribs. Boxes of fragments contained mostly bone and ivory pieces that belonged to both a mammoth and a large ungulate. The large ungulate fragments were identified by the root of a maxillary premolar and by the presence of smaller fragments with thinner cortical bone. Unfortunately, due to a lack of context, association with the mammoth remains could not be determined. However, sediment still adhering to the bones of the large ungulate shows a difference in soil colour compared to the sediment adhering to some of the mammoth bone fragments. The Munsell reading on the ungulate fragments were gray (10YR 6/1 dry) with nodules of yellow (10YR 7/8 dry), compared to the mammoth bones that had a reading of dark grayish brown (2.5 Y 4/2 dry). This would suggest that the ungulate remains would have been deposited in different sediment than the mammoth, most likely in the sediment above.

Individual elements are described in detail, including measurements and photographs, in Appendix B, however, an overview is provided here. The bones that were preserved denote roughly 20% (Figure 4.1) of the total skeleton of a woolly mammoth. Vertebral column elements represent the majority of the complete bones identified (see Table 4.1). Although many were not found in articulation when initially uncovered in 1964, some are situated close by or adjacent to each other in the articulated vertebral column. The appendicular skeleton is represented by the right side only and no bones are duplicated indicating that the MNI for these remains is one.

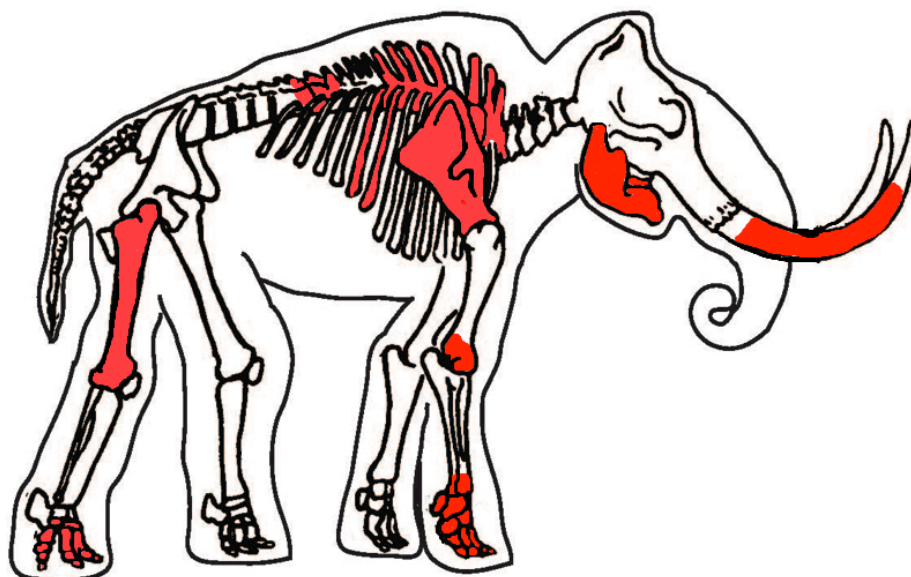


Figure 4.1 Schematic representation of the bones recovered of the Kyle mammoth.

Table 4.1 Bones Recovered of the Kyle Mammoth

Bone	Catalogue #	Side
Cervical Vertebra	1699.1 8810 B	N/A
1st Thoracic Vertebra	1699.1 8810	N/A
Thoracic Vertebra	1699.1 8810 C	N/A
Thoracic Vertebra	1699.1 8810 Display	N/A
Thoracic Vertebra	1699.1 8810 F	N/A
Thoracic Vertebra	1699.1 8810 I	N/A
Thoracic Vertebra	1699.1 8810 E	N/A
Thoracic Vertebra	1699.1 8810 G	N/A
Thoracic Vertebra	1699.1 8810 J	N/A
Thoracic Vertebra	1699.1 8810 H	N/A
Thoracic Vertebra	1699.1 8810 D	N/A
Thoracic Vertebra	1699.18810 K	N/A
Rib 1	1699.1 8810	Unknown
Rib 2	1699.1 8810	Left
Mandible	1699.1 8810	Right
Scapula	1699.1 8810	Right
Humerus	1699.1 8810 N	Right
Radius	1699.1 8810 M	Right
Ulna	1699.1 8810 L	Right
Forefoot (21 individual bones)	1699.1 8810	Right
Femur	1699.1 8810	Right
Hindlimb (19 individual bones)	1699.1 8810	Right
Tusk	1699.1 8810	Unknown

4.1 Axial Skeleton

The axial skeleton consists of 12 vertebrae, a mandible, and three ribs. One rib is missing from this catalogue as it was located in Eastend, Saskatchewan and was unobtainable for an osteological and taphonomic analysis. The vertebrae represent less than 25% of the entire vertebral column and the majority are from the thoracic portion. The mandible is one of the larger complete elements that were uncovered during the initial excavation. It contains two intact molars as well which aids in identifying species and age at death. The initial catalogue had included a separate molar that was found during excavation in 1964. Unfortunately, this molar could not be located in the collection and was not included in the new catalogue. It is, however, recorded on the site map (Figure 4.2) that was created during excavation and can be identified a few meters away from the lower jaw on the map. This makes for an unfortunate situation as the molar could have been used to aid in identifying some valuable information such as the age at death and species of the Kyle mammoth. Luckily the molars that are intact in the lower jaw can provide those answers.

The initial site map (Figure 4.2) only records eight vertebrae while the catalogue contains 12. In addition, one of the vertebra from the site map was completely destroyed for radiocarbon dating leaving five that were initially unidentified. One of the vertebrae did not preserve very well and so could have been misidentified or labeled as bone fragment during initial excavation. Another vertebra is only represented by the spinous process and may have been identified as a rib fragment initially. Others may not have been identified until they were taken out of the casts back at the museum. Regardless of the differing number of vertebrae from the initial excavation, all the vertebrae analyzed in the catalogue that was labelled under the Kyle mammoth were confirmed to have belonged to the same animal as preservation and age of each vertebrae were determined to be the same, or very similar.

The first vertebra (Figure B.1) is the only cervical vertebra in the catalogue and is identified by the catalogue number P1699.1 8810 B. The lack of costal facets on the centrum, the presence of transverse foramen, and the triangular shape of the vertebral foramen are typical of cervical vertebrae. Both the anterior and posterior centrum facets are completely fused with the suture lines fully obliterated. The spinous process was not preserved.

SITE EFOA-S KYLE MAMMOTH SITE

Oct. 19, 1964

Drawn by T. F. Kehoe

NEA Sec. 35 Twp. 25 N. R. 21 W. Long 108° 01'

discovered Oct. 17, 1964

by Rick Graham, William McEwen, J. Anderson

Letter from K.J. MacCallum

To Dr. E.A. Christianson

dated 11, March 1965

Kyle Mammoth Sample #S-24

Age & Sex 12,000 ± 200 years

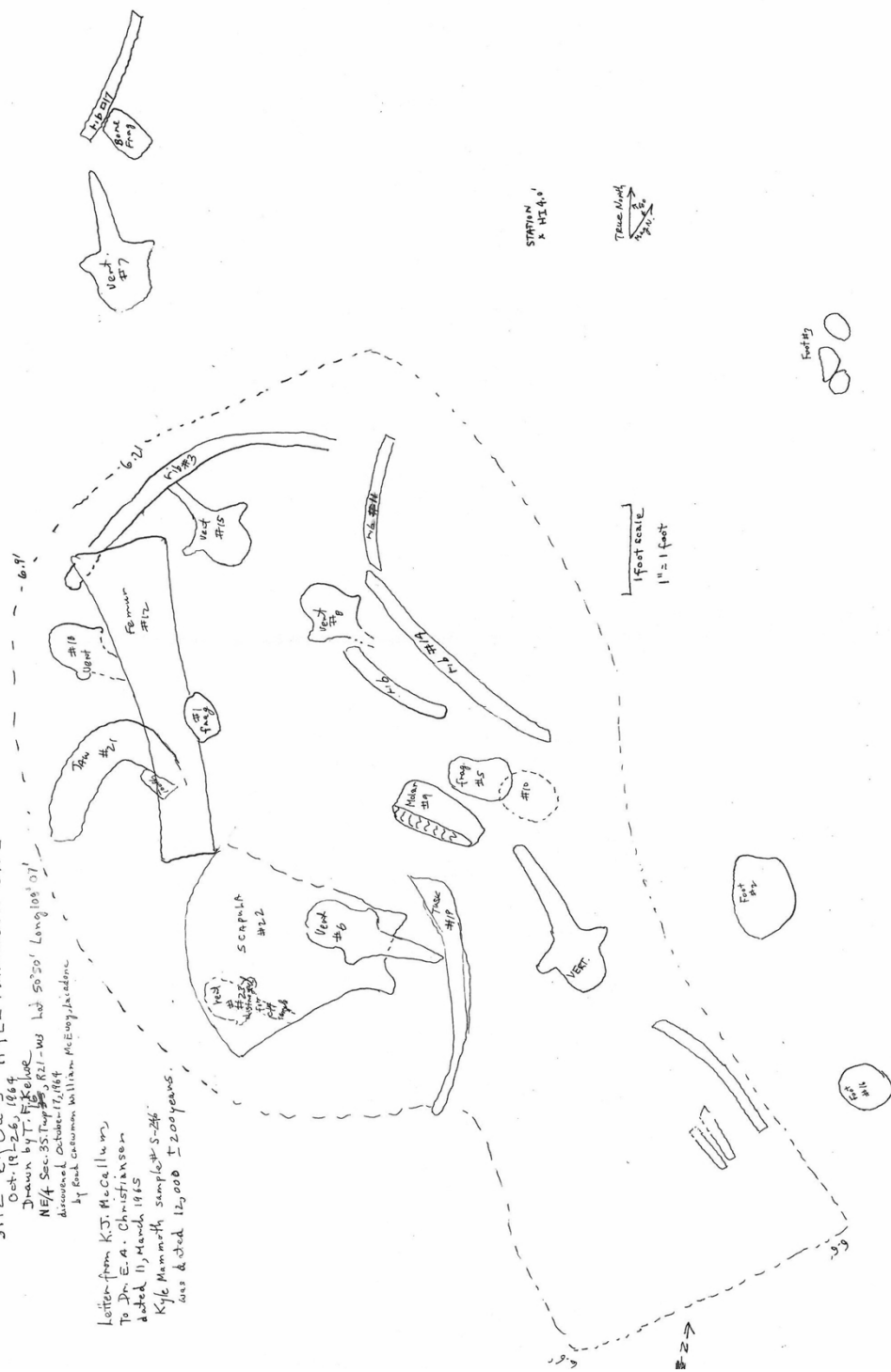


Figure 4.2 Original Site Map (1964) Bones Recovered by SMNH: #1- Bone Fragments (unidentified H1= 4.0'), #2- Foot Bones (5.2' b.d.), #3- Foot Bones (4.0'-5.4' b.d.), #4- Back of rib Fragments, #5- Fragmentary knob of Long Bone (wrapped), #6- Vertebrae in Block, #8- Vertebrae with upright spine, #9- Molar tooth (First found 3.5' b.d.), #10- Misc. unidentified Bones, #11- Rib, #12- Femur (5.0' b.d.), #13- blank, #14- Rib (3.6' b.d.), #15- Vertebrae (group of 3 articulated 4.2' b.d.), #16- Foot (5.9' b.d.), #17- Rib, #18- Vertebrae, #19- Tusk (3.9-6.6 b.d.), #20- blank, #21- Jaw (5.6' b.d.), #22- Scapula (5.5' b.d.), #23- Vertebrae (collected for C-14 sample Oct. 26 1964 by T. F. Kehoe 6'' sent to C-14 Lab Saskatoon Oct. 31 1964. 6'' below distal end of scapula. Extra carbon 14 sample in SMNH drawn (?) F16)

The second vertebra (Figure B.2) is the first thoracic vertebra and is identified by the catalogue label of P1699.1 8810. There are no transverse foramina and there are costal facets present on the centrum. However, the vertebral foramen is triangular in shape which is more characteristic of cervical vertebrae typical of the transition into the first thoracic vertebra. Both the anterior and posterior centrum articular facets are fully fused with the sutures completely obliterated as well. This vertebra is missing the left transverse process and the spinous process.

The third vertebra (Figure B.3) is a thoracic vertebra as it too contains costal facets and a lack of transverse foramina. It too, however, displays a triangular shaped vertebral foramen which would suggest it belongs to one of the first three thoracic vertebrae that are in transition from the cervical vertebrae. The anterior centrum facet is fully fused with the suture destroyed. The posterior facet is missing. Due to the presence of some billowing located on this facet, it is suggested that the epiphysis was in a state of fusing and would have broken off post deposition. Both transverse processes are present, although in a poor state of preservation. As well, the majority of the spinous process, which is projected almost vertically, is present excluding the very tip. This vertebra is identified in the catalogue as P1699.1 8810 C.

The fourth vertebra (Figure B.4) is the largest in this collection. It is identified by the catalogue identification of P1699.1 8810, but is differentiated from the rest by the dark colour that is a result from casting to create a mould. It is a thoracic vertebra as is evident by the prominent spinous process that is angled superior and posteriorly and the presence of costal facets on the centrum. It most likely represents a vertebra from around the seventh thoracic due to the slight V-shaped ventral curve of the centrum which can be seen from the anterior view. The posterior articular facet on the centrum is in the process of fusing as the epiphysis is fully attached, but still contains prominent sutures along the lateral edges of the centrum. The anterior facet is in a poor state of preservation with no definitive signs of an epiphysis. It is suggested that the epiphysis was in a state of fusing, like the posterior facet, and was lost post deposition. The vertebra is asymmetrical as the right transverse process has degraded substantially compared to the left side. Other than the degradation to the right transverse process and the anterior portion of the centrum, the vertebra is complete.

The vertebra identified by the catalogue number P1699.1 8810 F (Figure B.5) represents a thoracic vertebra. It contains costal facets and a long spinous process that angles superior and posteriorly. It belongs to the lower thoracic (T10-19) due to the thickening of the centrum

anterior-posteriorly and the rounding of the ventral surface of the centrum. Although it shows some signs of heavy degradation on the left and anterior portion, the vertebra is nearly complete. The posterior centrum facet is in a state of fusing with sutures still prominent. The anterior centrum facet is missing. However, a small amount of billowing present on the right portion of the centrum would suggest that the epiphysis was in a state of fusing, but like two of the previous vertebra presented, was lost post deposition.

The next vertebra (Figure B.6) is identified by the catalogue number P1699.1 8810 I. It too is a thoracic vertebra with costal facets and a projecting spinous process that is directed superior and posteriorly. It belongs to the lower thoracic (T10-19) due to the rounded ventral surface of the centrum and the increased thickness of the anterior-posterior centrum. It is nearly complete, but contains heavy degradation on the anterior and right side and a portion of the spinous process is missing. Both the posterior and anterior centrum facets had not begun fusing as is evident by the missing epiphyses and by the obvious billowing on the posterior centrum and the small amount that could be seen through the degradation on the anterior side.

P1699.1 8810 E (Figure B.7) is also a thoracic vertebra from the lower portion (T10-19). It is asymmetrical and heavy degradation on the right side has destroyed most of the transverse process and part of the centrum. However, other than the degradation, the vertebra is complete. The articular facet of the centrum on the posterior surface is in a state of fusing as the suture is still visible on the lateral edges. The anterior facet is missing, but billowing visible on the inferior portion suggests that the facet was in the process of fusing and was lost post deposition.

The eighth vertebra (Figure B.8) belongs to the lower thoracic (T10-19) group as is indicated by the rounded ventral centrum. It contains prominent costal facets on the posterior lateral portion and on the left lateral side. It was catalogued under the code of P1699.1 8810 G and is nearly complete except it is missing the majority of the spinous process and a partial portion of the left transverse process. Heavy degradation can be seen on the anterior surface, however, the centrum articular surface shows signs of billowing indicating that the anterior epiphysis had not begun fusing. The posterior surface, although not as heavily degraded also shows billowing on the centrum indicating that fusion of the epiphysis had not yet begun on this side as well.

The vertebra that is catalogued under the code of P1699.1 8810 J (Figure B.9) also belongs to the lower thoracic (T14-19) vertebrae. The slight curvature of the inferior articular

process and the single costal facets on the lateral edges of the centrum suggests that the vertebra is in transition to lumbar vertebrae and belongs to the most posterior group of thoracic vertebrae. It also contains a rounded ventral surface on the centrum and has a thickened centrum anteriorly-posteriorly. The left lateral edge exhibits heavy degradation surrounding the costal facet, transverse process, and anterior surface and the spinous process is incomplete. Other than those portions, the vertebra is nearly complete. Both the anterior and posterior centrum epiphyses are present and in the process of fusing as are evident by the prominent suture lines visible on the lateral edges of the centrum.

P 1699.1 8810 H (Figure B.10) is a heavily degraded specimen although costal facets were visible on the lateral edges indicating that this vertebra still belongs to the thoracic group. The rounded nature of the ventral surface of the centrum indicates that this specimen belongs to the lower portion of thoracic vertebra with the curve of the inferior articular processes indicating that a transition into the lumbar vertebrae is evident (T14-19). The posterior surface of the centrum shows obvious billowing indicating that fusion of the epiphysis may have begun, but was not complete. The anterior epiphysis is still present and in the process of fusing as is indicated by the visible suture lines on the lateral edges of the centrum. The anterior portion of the vertebra is well preserved, however, the posterior aspect has gone through heavy degradation and is missing portions of both transverse processes and the majority of the spinous process and the superior portion of the posterior centrum.

The last almost complete vertebra is catalogued under the code P 1699.1 8810 K (Figure B.11). This vertebra is in an extremely poor state of preservation as the posterior portion is almost obliterated due to weathering with the anterior portion still partially intact. The spinous process and the inferior and superior articular facets are absent. No prominent costal facets could be identified on the lateral edges which may be due to the state of preservation. However, the shape of the vertebral foramen would suggest that this vertebra might have belonged to the lumbar portion of the vertebral column. Without facets to confirm, this vertebra has been labelled as unknown from the lower vertebral column. The anterior facet of the centrum shows prominent billowing, which is indicative of an unfused epiphysis. The posterior facet was completely obliterated and so fusion state of the epiphysis could not be determined.

A single spinous process (Figure B.12) belonging to a thoracic vertebra was also uncovered. It was identified as such due to the overall length and the presence and shape of the

inferior articular process. The preservation is very good, but unfortunately a more specific vertebra number could not be identified due to the incompleteness of this specimen. The catalogue number given was P 1699.1 8810 D.

The two ribs that were examined included a heavily fragmented portion of a rib (Figure B.13) and an almost complete rib (Figure B.14). The heavily fragmented piece could not be identified to side as the costal groove could not be located. The head of the rib is missing, but the majority of the body and the rib angle are present although very fragmented. The second rib is more complete and contains both the head and the sternal end of the rib. It is fairly well preserved and is from the left side. Unfortunately, without a comparison to the more posterior ribs an exact position of these ribs could not be determined. In addition, a portion of another rib was found in the boxes of fragments. It represents the angle portion of the rib. Little else could be discerned from the fragment although it was preserved well and found in the fragment box labelled P1699.11 8810.

The last bone representing the axial skeleton of the Kyle mammoth is the lower right mandible with molars (Figure B.15). Although slightly fragmented, the jawbone is intact and is only missing the condyle, the very superior portion of the coronoid, the anterior portion of the mandibular symphysis, and the lingual portion of the body and angle that exposes the M₆ molar in the alveolar cavity. Two molars are present in the alveoli cavity that represents the M₆ molar in the posterior portion and the M₅ molar in the anterior portion. The molars will be described a little more in detail later in this chapter as they pertain to the identification of species and age at death.

4.2 Appendicular Skeleton

Four limb bones and two articulated feet represent the appendicular skeleton from both the hind and fore limb. The two articulated feet, one from the forelimb and one from the hindlimb, represent 40 individual elements that could be identified that included sesamoid bones and phalanges. The majority of the articulated feet are present except for a few carpals and tarsals. The forelimb is described first as it represents the most complete out of the two limbs.

The scapula (Figure B.16) is one of the more complete larger bones that were uncovered in 1964. It is in an extremely fragile state and did not preserve well. However, it was recovered intact only to be thoroughly covered in adhesives to the point that the majority of the surface of the bone is no longer visible. This made finding suture lines difficult although the superior

epiphyseal surface was visible. Billowing on this surface indicates that the epiphysis had not yet fused, but may have been in the process of fusing and was lost post deposition. The acromial process and spine of the scapula are present although the posterior projection of the spine is fragmented. The anterior border is also partially missing.

Only the distal medial portion on the right side represents the humerus (Figure B.17). It is heavily fragmented as can be seen from the medial edge. The articular surface, in contrast, is well persevered with a portion of the trochlea present. The epiphysis is fully fused and the sutures obliterated.

The distal radius and ulna (Figures B.18 and B.19) are both present in this collection. The radius is well preserved except for some minor weathering on the medial edge. It represents only the epiphysis of the radius and is unfused as is indicated by billowing on the superior portion. The ulna is also in a good state of preservation with only minor weathering on the lateral edge. It too is only the distal epiphysis of the long bone and, just like the radius, contains billowing on the superior surface. The humerus, radius, and ulna were all identified using Olsen (1979) as a comparison and are identified in the catalogue with the code P1699.1 8810 N (humerus), M (radius), L (ulna).

The forefoot (Figure B.20) of the Kyle mammoth was uncovered almost fully articulated. It contains 5 carpals and three complete digits. The carpals consist of the lunar, magnum, trapezoid, scaphoid, and pisiform that is not articulated with the rest of the carpals. The digits include numbers 2, 3, and 4, and all have the metacarpals and three phalanges except digit 2, which is missing the third phalanx. The distal epiphysis of metacarpal 2 is in a state of fusion as is evident by the visible suture line. However, metacarpals 3 and 4 appear to be fully fused, as no suture line is visible. All of the bones in this foot preserved very well including the six sesamoid bones that are articulated on the posterior side of the distal ends of the metacarpals. In total, 21 bones make up the articulated forelimb in the Kyle mammoth.

Two elements, the femur and the articulated foot represent the hindlimb. The femur (Figure B.21), which is the largest of the intact bones recovered in 1964 is fairly well persevered except for a number of weathering related cracks on the shaft. Both the distal and proximal epiphyses are missing as only prominent billowing is present at both ends.

The hind foot (Figure B.22) was not as well preserved or correctly articulated as the fore foot and differentiation of individual elements was more difficult. The internal and external

cuneiform was identified in their articulated position with the cuboid located posteriorly from its proper articulation. The complete digits' present are 1, 2, and 3, with digit 3 is missing the third phalange. The metatarsal of digit 4 is present as well, but is in a very poor state of preservation. Five sesamoid bones are also present on the posterior and inferior side and are in varying states of preservation. Two other smaller bones are also present, but could not be identified to a specific location. The most likely identification of these bones is another sesamoid bone and the third phalange of one of the remaining digits. The second phalange of digit 2 shows a prominent epiphyseal suture on the proximal portion of the inferior surface. Sutures on the other digits could not be identified most likely due to the lack of preservation, but also could be due to complete epiphyseal fusion and the obliteration of the sutures.

The height of the Kyle mammoth was calculated using the scapula since this was the most complete out of all the limb bones. A recent study conducted by Larramendi (2015) compiled long bone measurements and obtained average ratios for each long bone to the overall skeletal shoulder height that also included soft tissue. The maximum length of the scapula (HS in Appendix 1) was multiplied by the ratio 3.34 as calculated by Larramendi (2015) for *Mammuthus primigenius*. This gave an average minimum skeletal shoulder height for the Kyle mammoth 328 cm! This is the average height of a fully-grown male *Mammuthus primigenius* (Haynes 1991). The body mass, which was also calculated by Larramendi (2015), would be between 6 and 6.9 tons. Considering that many of the long bone epiphyses have not yet fused, the Kyle mammoth was still growing and would have been above average height for a woolly mammoth, but not as large as *Mammuthus columbi*.

4.3 Bone Fragments

Five boxes of bone fragments accompanied the Kyle mammoth in the museum and were collected during excavation and post excavation from the ditch. Each box was weighed and sorted through to see if anything was identifiable. One rib was already mentioned previously. The first box of fragments weighed 509 grams and was catalogued under the number P1699.8 8810. It contains pieces of ivory, long bone fragments and skull fragments which were identified by sutures, but could not be identified to specific element in the cranium. It also contained a fragment of spongy bone with some taphonomic markers that will be discussed in the next chapter.

Two boxes were catalogued under the label P1699.9 8810 and P1699.10 8810 and weighed 107 grams and 218 grams respectively. They both contained smaller pieces of bone and ivory, but nothing that could be identified to an element.

Box P1699.11 8810 was the largest of the five boxes. It weighed 1484 grams and contained fragments of long bone, ivory, skull fragments, and the bison fragments that were mentioned previously in this chapter. One fragment was of substantial size weighing 203 grams alone and may have belonged to either the distal or proximal ends of a long bone or may have been part of the carpals or tarsals. Unfortunately, the element was too fragmented to identify without a comparative collection.

The last box was catalogued under the code of P1699.12 8810. It weighed 160 grams and contained fragmented pieces of the epiphysis of the vertebral centrum. Unfortunately, the fragments could not be identified to a specific vertebra.

4.4 Sex

Sex determination in the Kyle mammoth was predominately based on the tusk size and shape since no pelvis was recovered. The epiphyseal fusion and age association was also a contributing factor in sex determination and that will be discussed below. Sexual dimorphism present in the tusk of woolly mammoths is more apparent closer to the alveolar cavity. The diameter measurement at this location has shown that female woolly mammoth tusks tend not to exceed 90 mm. Conversely, male woolly mammoth tusks can grow up to 200 mm in diameter at the proximal end (Averianov 1996).

The tusk belonging to the Kyle mammoth was incomplete. The proximal and distal portions of the tusk were identified, however, the ends were extremely fragmented and an accurate measurement of the diameter was difficult to obtain. Instead, three circumferential measurements were made along the tusk at the proximal, distal, and midshaft locations and an average measurement calculated. The average circumference was then converted into an average diameter measurement of 176 mm. This exceeds the average size of female woolly mammoths and thus the Kyle mammoth was determined to be a male. Moreover, the tusk of female woolly mammoths tends to be gracile and have a slight medial curvature. The tusk belonging to the Kyle mammoth is very robust, even in its fragmented state, and has a prominent medial curvature that, according to Averianov (1996) is characteristic in males. In addition, the epiphyseal fusion in correlation to the age of the mammoth also confirms that this mammoth is in fact a male.

4.5 Age at Death

The age at death was determined using two lines of evidence. The first was by looking at the fusion between diaphysis and epiphysis of the long bones present. This included the scapula, distal humerus, distal ulna, distal radius, and femur. These surfaces were then graded on the state of fusion they represented, which were fused, unfused, or fusing. Fused represents the stage at which the diaphysis and epiphysis are completely ossified and no suture is visible. Unfused represents the stage at which the epiphysis and diaphysis are completely disarticulated and the epiphyseal surface of the diaphysis is fully exposed. Fusing is the stage at which the epiphysis and diaphysis are articulated and the suture is highly visible. The growth of *Mammuthus* coincides closer to the development of the Asian elephant according to Haynes (1991). Therefore, observations in modern elephants can give a rough estimate as to the age of the extinct species. In this case the Kyle mammoth should be compared to the Asian elephant when the data for comparison is available.

Lister (1999) compiled a study of epiphyseal fusion in long bones of *Mammuthus primigenius* to determine at what age long bones fused and in what order. Twenty individual mammoths were evaluated and aged based on dentition of African and Asian elephants and a distinctive pattern in long bone fusion that was observed. Lister determined the order of long bone fusion in *Mammuthus primigenius* was distal humerus, proximal and distal tibia, proximal radius and ulna and distal femur, proximal humerus and scapula, proximal femur, and lastly distal radius and ulna. This is a rough estimate and individual variations and sex could account for some discrepancies in the order of fusion (Haynes 1991). Thus, this order is only a guideline and other lines of evidence in age determination should be consulted.

Unfortunately, Lister (1999) did not cover the superior angle of the scapula, which also contains an epiphysis, in his fusion sequence. He also does not define the proximal scapula. This creates an issue as more than one ossification surface is present in that general region. For that reason, the proximal scapula will be omitted from the age determination. Moreover, very few publications address the fusion of the scapula and in particular the superior angle portion. The only reference that could be found to this portion of bone was in publication by Roth in which she states "...except for the femur, in which the ossification center for the greater trochanter remains separate late into ontogeny, and the scapula, which may be considered to have a single epiphysis, on the vertebral border" (Roth 1984:127). Based on this statement, the superior angle

of the scapula will be considered in Lister's sequence of fusion as congruent with the fusion of the proximal femur.

The Kyle mammoth's long bones mentioned above are listed in Table 4.2 with their respective fusion state. When compared to Lister's sequence of fusion, the Kyle mammoth fits well into the age range of 23 years of age to a maximum of 30 years of age (Asian elephant). The distal humerus at this age is already fully fused with the distal femur falling next in line to begin fusing. Since both the distal and proximal ends of the femur, the distal radius, the distal ulna, and the superior angle of the scapula are all still unfused in the Kyle mammoth it was determined that the maximum age could not exceed 30 years. Regrettably, the lack of a tibia and proximal ulna in this collection could not narrow the age range further in this specimen based on epiphyseal fusion.

The second lines of evidence used in age determination for the Kyle mammoth were the intact molars present in the right mandible. Based on the lamellar frequency obtainable in the erupting molar (20+) it was determined that this molar represents M₆ and the anterior molar represents M₅ (Maglio 1973). Some authors prefer to denote the succession of the six-molariform teeth using dP2-dP4 and M1-M3, but for simplicity sake M1-M6 will be used here as it coincides with the references used.

Laws (1966), and a revision conducted by Jachmann (1988), published the evolution of teeth with corresponding age determination in African elephants based on occlusal wear and eruption sequences. Roth and Shoshani (1988) also published a similar article relating to Asian elephants. These publications were used as a proxy for age determination in the Kyle mammoth. Based on their stages of eruptions and corresponding age groups, it was concluded that the occlusal wear existing on the Kyle mammoth's molars M₅ and M₆ and the stage of eruption of M₆ coincides in between the age groups of XXI and XXII as defined by Laws (1966). The M₅ molar from the Kyle mammoth shows heavy occlusal wear on the lamellae with the anterior plates in the process of breaking off anteriorly. The M₆ molar had begun to erupt out of the alveolar cavity and the first couple of lamellae began to wear on the occlusal surface.

In order to account for the differences in the number of plates between *Mammuthus* and *Loxodonta*, the ratio of lamellae remaining on the Kyle mammoth's M₅ was compared to the ratios of lamellae remaining on the M₅'s of African elephants in each stage of eruption set out by Laws (1966). Thus the Kyle mammoth's molars suggest this mammoth falls in between the age

Table 4.2 Long Bone Epiphyseal Fusion State

Element	Side	Completeness	Epiphyseal Fusion
Scapula	Right	Almost Complete	Unfused Superior Angle (Figure 4.3)
Femur	Right	Diaphysis Complete	Unfused Proximal and Distal (Figure 4.4)
Humerus	Right	Distal Lateral Condyle	Fused
Radius	Right	Distal Epiphysis	Unfused
Ulna	Right	Distal Epiphysis	Unfused

groups of XXI and XXII. These age groups are estimated to represent elephants 36 ± 2 and 39 ± 2 years of age (Laws 1966). This also agrees with Roth and Shoshani's (1988) age representation as well. Based on the ratios of lamellae remaining in stages recorded in *Elephas*, the Kyle mammoth would fall into the age category of 34 years old (Roth and Shoshani 1988).

The differing lines of evidence now need to be combined in order to account for the dissimilar age ranges from the epiphyseal fusion sequence and molar eruption. The epiphyseal fusions of male elephants ossify 7 to 13 years later than females (Haynes 1991; Lister 1999). This is due to the fact that female African elephants are all but done growing roughly around the age of 25 and males continue to grow until the age of 45 (Lister 1999). Lister's study on fusion in *Mammuthus primigenius* was predominately male and thus more relevant to the Kyle mammoth. As stated before, due to the unfused distal epiphysis of the femur the Kyle mammoth could not exceed 30 years of age. However, if fusion had only just begun in the distal epiphysis of the femur before death and evidence of this minimal fusion is all but lost. This would increase his age into the early to mid 30's that would then agree with Roth and Shoshani's (1988) age estimation using Asian elephant teeth. Based on these deduced assumptions on epiphyseal fusion and tooth eruption, the Kyle mammoth would fall into the age range of 28 to 35 years of age, give or take a few years for individual variation. The minimal age of 28 years accounts for the unfused epiphysis of the distal femur and maximum age of 35 years accounts for the eruption stage of the M₆ molar.

4.6 Taxonomy

The order Proboscidea contain a wide diversity that has its beginning in Northern Africa roughly 50 million years ago (Haynes 1991; Webb 1992). The genus *Mammuthus* belonging to this order only appears roughly 3 to 4 million years ago in sub-Saharan Africa. By the beginning of the Pleistocene, they became extensive in Eurasia and by 1.7 million years ago they had



Figure 4.3 Superior portion of scapula showing billowing indicating ossification has not occurred yet.

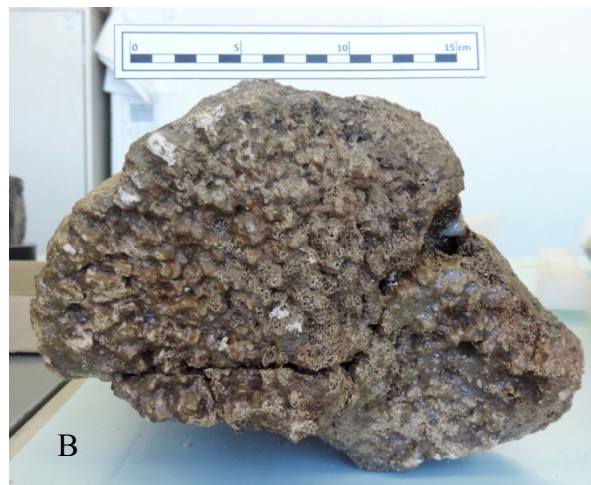


Figure 4.4 Proximal (A) and distal (B) femur showing prominent billowing indicating that epiphyseal ossification had not occurred.

migrated into North America via Beringia (Haynes 1991; Maglio 1973; Webb 1992). Debate still centers on whether a second migration of *Mammuthus* brought the more northerly species *Mammuthus primigenius* that differs from *Mammuthus columbi*, which is descended from the first migration of *M. meridionalis*. Postcranial morphology suggests there is no difference between the two species except in tooth enamel (Haynes 1991). Haynes (1991) suggests they were geoclineal dispersal variants developing differing tooth morphologies over time. Maglio (1973) compiled a study in which specific measurements of teeth belonging to different genera in the family Elephantidae exhibited specific morphometric traits fitted to each species.

The species of the Kyle mammoth was determined using the M₆ molar of the right mandible and comparing it to the study conducted by Maglio (1973). Table 4.3 shows the seven traits that were measured and how they compare to the measurements of the species *Mammuthus primigenius*. The plates were counted by examining the lamellar loops present on the lingual surface. The addition of the + sign is to indicate that on the posterior surface plates are lost due to a lack of preservation and also accounts for the possibility that the tooth was still in a state of development within the alveolar cavity and would have eventually developed more plates. Moreover, the anterior surface is obstructed by post-excavation addition of casting cement to support the structure of the fragile bone. The counting of plates could not be conducted on the buccal surface as the mandible and alveolar cavity obstructed the majority of the tooth.

The length was measured according to Maglio's (1973) description. Due to the inaccuracy between the measurement taken at the crown root and the occlusal surface, the third variation suggested a measurement taken perpendicular to the average lamellar plane (Maglio 1973). This was taken roughly halfway between the root of the crown and the occlusal surface beginning at the casting cement and ending at the furthest extent of the posterior fragmentation which resulted in a line that was slightly acute with the occlusal surface. Due to the poor state of preservation of the tooth, and possibly the underdeveloped state, the length is only an estimate as the casting cement obstructed the very anterior portion of the tooth and cracks developing in the plates will also skew the results slightly. These measurements are shown in Figures 4.5 and 4.6.

The width of the tooth could not be measured accurately due to, once again, the mandible obstructing the buccal surface. A width measurement was taken along plate 10 (P10) just above the mandibular bone to aid in estimating the actual width of the tooth within the alveolar cavity. The tooth continues to widen well into the alveolar cavity and was estimated to be between 85

Table 4.3 Molar Radiometrics for the Kyle Mammoth vs Maglio's (1973) Measurements

	Kyle Mammoth	<i>Mammuthus primigenius</i>
Plate Number (P)	20 (+)	20-25
<i>Mean</i>		21.8
<i>Standard Deviation</i>		1.9
Length (L in mm)	321 ^c (+)	207.0-320.2
<i>Mean</i>		267.4
<i>Standard Deviation</i>		44.1
Width (W in mm)	78.5 ^{P10 c}	65.0-100.0
<i>Mean</i>		87.6
<i>Standard Deviation</i>		10.9
Height (H in mm)	176.79 ^{P10}	123.0-184.1
<i>Mean</i>		87.6
<i>Standard Deviation</i>		20.9
Lamellar Frequency (LF)	6.75 ^b	6.8-10.2
<i>Mean</i>		8.5
<i>Standard Deviation</i>		1.1
Enamel Thickness (ET in mm)	1.75 ^b	1.3-2.0
<i>Mean</i>		1.5
<i>Standard Deviation</i>		0.3
Hypsodonty Index (HI)	N/A	137.8-189.2
<i>Mean</i>		159.7
<i>Standard Deviation</i>		19.8

and 100 mm wide. Due to difficulty of obtaining an accurate width measurement a true hypsodonty index could not be calculated and has been omitted from the analysis.

The crown height was measured along plate 10 (P10) on the lingual surface as this was determined to be the highest point along the tooth. Calipers were used to measure from the highest point on the occlusal surface of the plate down to the crown of the same plate in order to keep the line parallel with the plate.

The lamellar frequency was taken at four different locations on the tooth within a ten-centimeter span (or 100 mm) to account for the curvature of the tooth. Only complete lamellar folds with cement intervals were counted within the ten-centimeter span. The locations for the measurements were taken on the lingual and buccal surfaces close to the apex and base of the crowns. For the base measurement on the buccal surface, a measurement was taken along the tooth just above the mandibular bone as the mandible obstructed the base. The average was then obtained from the four measurements. However, due to the inaccuracy of the fourth

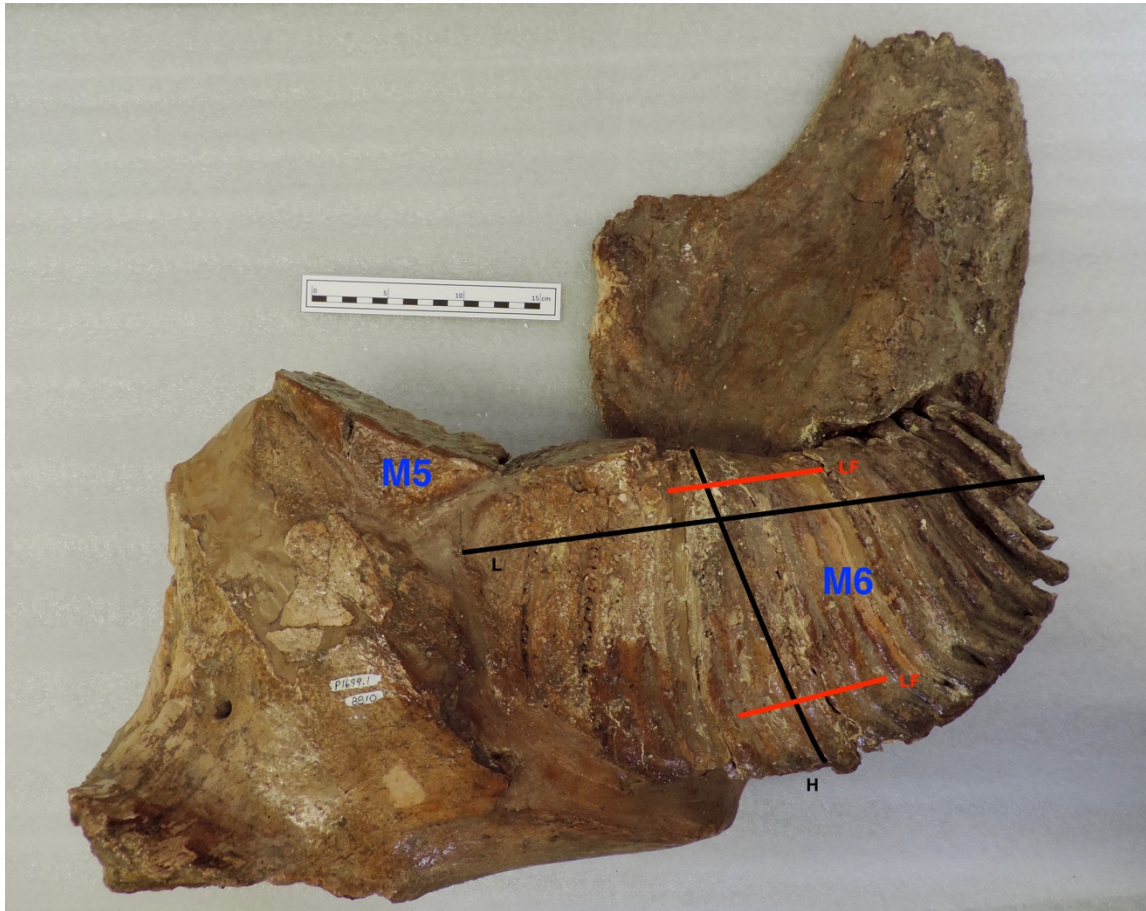


Figure 4.5 Location of measurements taken on the lingual surface of M_6 .

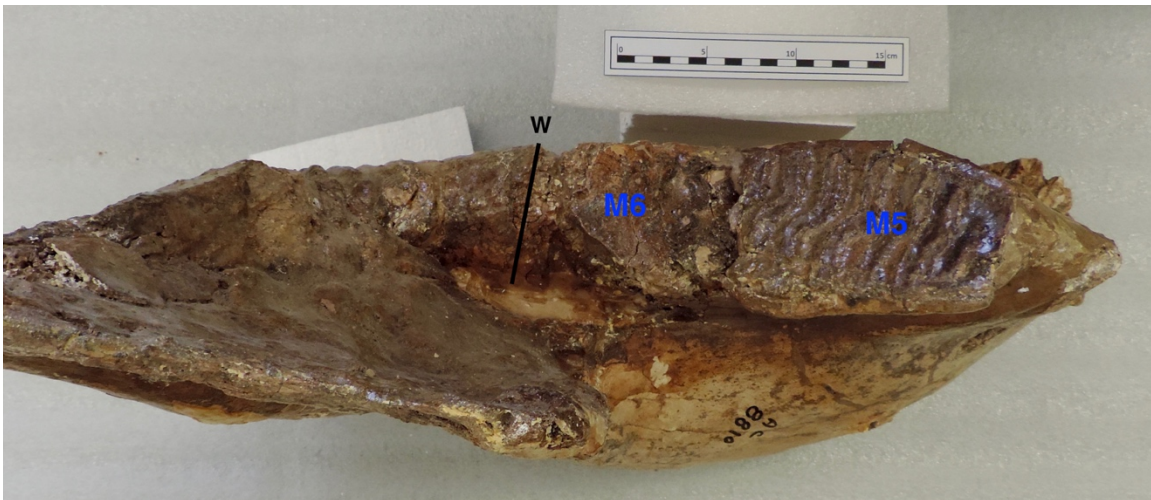


Figure 4.6 Location of measurements taken on the occlusal surface of M_6 .

measurement it is likely that the average is skewed slightly, but not so much that the final result will be altered. In addition, cracks present within the plates would also skew the results slightly and have been taken into consideration with the final results.

The enamel thickness was difficult to obtain due to the small amount that was not obstructed by cementum. Care was taken to avoid measurements at folds as was suggested by Maglio (1973) due to the thickening of enamel in these areas and the angle of measurement was taken as close to perpendicular to the outer face as possible to account for the inaccurate thickening due to the oblique nature of the occlusal surface. A series of thicknesses were measured and an average was obtained.

Table 4.3 shows that the M₆ molar belonging to the Kyle mammoth is well within measurements summarized by Maglio (1973) for *Mammuthus primigenius*. Therefore, it has been concluded that the Kyle mammoth belongs to this species.

4.7 Summary

The osteological analysis that was conducted on the Kyle mammoth allowed me to ascertain three important characteristics. The mammoth was a male as was indicated by the diameter of the tusk. The mammoth was between the ages of 28 and 35 years of age at the time of its demise as was evident by the epiphyseal fusion of the long bones and the eruption stage of the last molar. Lastly, the mammoth was of the species *Mammuthus primigenius* which differentiates it from its nearest relative to the south *Mammuthus columbi*. In addition, the osteological analysis confirmed that the Kyle mammoth was in fact a single individual that was found and the length of the scapula revealed that the mammoth stood roughly 328 cm at the shoulders and had a body mass of roughly six tons. This mammoth was not yet fully grown and would have been above average in size and weight for his kind if he had another six to ten years to live into his prime and let his long bones fully fuse. Unfortunately, he did not make it to that age and a taphonomic analysis was completed in the hopes of revealing the cause of death for this animal. That analysis is the focus of the next chapter.

Chapter 5

Taphonomic Analysis

The study of taphonomy provides a wealth of information about an organism immediately after death. Natural agents in the biosphere, including biotic and abiotic, leave key markers on the remains of other living organisms providing information on the depositional history and possible utilization of these remains. The important factor in the study of taphonomy is the ability to differentiate between these markers. Some markers are similar in morphology, but the diagnosis of any given marker could suggest two or more different lines of conception. Experimental archaeology and observational comparisons are important in the gathering of data that can aid archaeologists determining the taphonomic background of a site. In the case of the Kyle mammoth, the taphonomic study aids in providing a depositional history of the remains and the possible modification created by biotic agents. The archaeological perspective in this case study is the investigation of any human modification to the bones which is included in this taphonomic study and separates it from a strict paleobiological analysis.

5.1 Postmortem Taphonomy

The results from the weathering taphonomic study are summarized in Table 5.1. Only the identifiable and whole bones are presented here. Taphonomic markers that were found on the bones of the Kyle mammoth were grouped under one of three categories: (1) natural taphonomy, (2) modern anthropogenic markers, and (3) butchering markers. Each category is further subdivided to differentiate all the agents that encompass that category. A brief description of these taphonomic agents that were relevant to the Kyle mammoth are given here.

5.1.1 Natural Taphonomy

Weathering agents in taphonomy refer to the abiotic mechanisms that breakdown bone into smaller pieces. These agents could refer to the sun, wind, water, and sediment. Natural

Table 5.1 Stages of Bone Weathering by Behrensmeier (1978) on the Kyle Mammoth

Bone	Catalogue #	Side	Stage of Weathering Cranial/Caudal		Position of Deposition
Cervical Vertebra	1699.1 8810 B	-	2	4	Anterior down
1st Thoracic Vertebra	1699.1 8810	-	1	3	Anterior down
Thoracic Vertebra	1699.1 8810 C	-	2	4	Anterior down
Thoracic Vertebra	1699.1 8810 Dis	-	4	1	Posterior down
Thoracic Vertebra	1699.1 8810 F	-	4	2	Posterior down
Thoracic Vertebra	1699.1 8810 i	-	5	3	Posterior down
Thoracic Vertebra	1699.1 8810 E	-	5	3	Posterior down
Thoracic Vertebra	1699.1 8810 G	-	4	1	Posterior down
Thoracic Vertebra	1699.1 8810 J	-	5	2	Posterior down
Thoracic Vertebra	1699.1 8810 H	-	2	5	Anterior down
Thoracic Vertebra	1699.1 8810 D	-	2	2	Undetermined
Lumbar Vertebra	1699.1 8810 K	-	3	5	Anterior down
Rib 1	1699.1 8810	Unknown	2		Undetermined
Rib 2	1699.1 8810	Left	2	2	Undetermined
Mandible	1699.1 8810	Right	2 (Buccal)	3 (Lingual)	Undetermined
Femur	1699.1 8810	Right	2	1	Undetermined
Scapula	1699.1 8810	Right	5 (Lateral)	5 (Medial)	Undetermined
Hindfoot	1699.1 8810	Right	4		Undetermined
Forefoot	1699.1 8810	Right	1		Undetermined
Tusk	1699.1 8810	Unknown	4		Undetermined
Radius	1699.1 8810 M	Right	3		Articular facet down
Ulna	1699.1 8810 L	Right	3		Articular facet down
Humerus	1699.1 8810 N	Right	2		Articular facet down

deterioration of bone occurs at a steady and rapid rate once protective tissue surrounding it has disintegrated and they are left exposed at the surface to any of the weathering agents.

Behrensmeyer (1978) documented six stages of bone weathering caused by a combination of fluctuating temperature and moisture at the ground surface. The first stage, stage 0, is characterized by fresh bone that has not yet begun to deteriorate. Stage 1 is indicated by the appearance of small parallel cracks that align with the bone structure. As well, mosaic cracking may be present on articular surfaces. Thin flaking appears in stage 2 usually occurring along edges of cracks that appeared in stage 1. These flakes are still attached in the earlier part of this stage and begin to deepen and fall away in the later portion. Cracks also deepen but remain angular. Stage 3 is characterized by rough compacted bone with the absence of the outer surface that disintegrated in stage 2. The edges of cracks have become rounded in this stage. Stage 4 is represented by very fibrous bone that is coarse in nature. The bone may begin to splinter with weathering removing the bone structure. Lastly, in stage 5 the bone begins to fall apart with splinters falling off exposing the trabecular bone. The original shape of the bone may be difficult to observe at this stage (Behrensmeyer 1978).

Although arbitrary, the stage of weathering determined on a bone is guided by a set of rules. These rules are: (1) each stage must have a covering of more than 1 cm² on any given bone, (2) the shafts of long bones and the flattest area of irregular bone are a priority for observation, and (3) the most advanced stage is recorded if two or more stages are observed. In many occasions the side of a bone that is in contact with the surface is less weathered than the side that is facing upward to the elements (Behrensmeyer 1978). The bones of the Kyle mammoth all show signs of different stages of weathering indicating that they were, for a period of time, exposed at the surface. Subsequent burial of some of the bones preserved them until discovery in 1964. Moreover, some of the bones show clear signs of how the bone was positioned at the surface prior to burial as the majority of the vertebrae exhibit heavy weathering on the anterior portion with a lesser stage of weathering on the posterior.

The water table also minimally contributes to the breakdown of bone. Ground water leaches elements such as potassium, sodium, chlorine, and magnesium, for example, from the bone. In addition, ground water also brings in large amounts of silica which becomes deposited within the bone. Over millennia silica deposits eventually fossilize the bone (Schiffer 1987).

The sheer weight of sediment that overlies bone can also have a significant impact. During the fossilization process, sediment is able to warp the shape of bones from the weight pressing downward (Schiffer 1987). In addition, sediment is able to fracture bone if it is laid down fast enough such as in areas of heavy sediment transport and deposition. This gives the appearance of dry fracturing in long bones and, more often, in thinner more fragile bones such as the ribs (Holen 2006).

Biological agents in taphonomy refer to living organisms causing deterioration or damage to the bones of deceased organisms. These includes large animals, carnivores, rodents, and plants. Damage to the bones caused by large animals is usually seen in the form of trampling when the bones are still exposed at the surface. Trampling is usually caused by herds of large animals such as bison, deer, or mammoths resulting in trampling for constant duration that may span a short (Dominguez-Rodrigo et al. 2009) or longer (Olsen and Shipman 1988) periods of time. Trampling marks are difficult to distinguish from cut marks, however, certain characteristics do set them apart. Experiments conducted by Dominguez-Rodrigo et al. (2009) and Olsen and Shipman (1988) concluded that cut marks created by utilized flakes and retouched flakes tend to be deeper than they are wide whereas trampling marks are fairly broad and shallow with a flatter base (Dominguez-Rodrigo et al. 2009; Haynes 1991; Olsen and Shipman 1988). The shoulders of the grooves created in trampling tend to flake and become more round in shape than in cut marks. Trampling also produces fine striae that tend to intersect at oblique angles of one another causing microabrasions with microstriations occurring most often at the bottom of the groove. Lastly, the grooves of trampling marks are more often sinuous in nature rather than straight (Dominguez-Rodrigo et al. 2009).

In addition, trampling can cause fracturing of long bones that may resemble intentional bone breakage patterns. Haynes (1991) observed juvenile elephant bones with a lack of epiphysis that were exposed at the surface with spiral fractures caused by trampling. Spiral fractures are helical fractures that lack a right angle break to the long bone shaft. They can be indicative of butchering patterns related to bone marrow extraction. The differentiation between intentional bone breaking for marrow extraction and bone fracturing caused by trampling is in comparison with other more fragile bones found in association with the spiral fractures. Haynes (1991) observed that rib bones and thin irregular bones such as the scapula were heavily fragmented due to trampling in association with the spiral fracturing found on long bones in the same assemblage.

In contrast, Holen (2006) observed spiral fracturing of long bones with minimal fracturing to thinner more fragile bones concluding that long bones were intentionally being targeted for marrow extraction and bone tool making. Holen (2006) also argues that the spiral fracturing that Haynes (1991) observed was primarily on juvenile long bones which lack an epiphysis and therefore naturally weaken the structure of the long bone. The adult long bones that Holen (2006) presents are far stronger than juvenile bones and could not be broken by mere trampling mechanisms.

Carnivore and rodent gnawing can also cause fracturing of long bones in addition to abrasive marks. They typically begin by gnawing at the epiphyseal ends and devour these portions before beginning work on the diaphysis (Haynes 1988; Holen 2006). In young animals this is often easily accomplished due to the lack of fusion of the epiphysis. Once the epiphysis is devoured the structure of the long bone is compromised and weakened therefore making it easy to fracture due to constant pressure of gnawing (Haynes 1988; Holen 2006). Spiral fracturing, in most cases, occurs when the carcass has been left to dry for a number of weeks or months. The microstructure of some bones, which are arranged longitudinally and helically, will crack along the weak faces. Scavenging carnivores will subsequently gnaw on the weak structure and spirally fracture the bone (Haynes 1980). In larger animals, such as elephants, the fracturing of long bones caused by carnivores is less likely due to the strength and thickness of the long bones. In the case of mammoths, even the very large short-faced bear (*Arctos simus*) would not be able to spirally fracture a long bone at midshaft without weakening the distal or proximal epiphysis first (Holen 2006). Thus, in the case of spiral fractures caused by carnivore gnawing, it is important to distinguish the extent of gnawing at the epiphysis. Furrows and scouring are usually the markers that are evident of carnivore gnawing and are usually located on the distal and/or proximal ends of long bones or on the processes of the vertebrae. Scouring leaves a rounded shallow groove along the shaft portion of the bone that is usually parallel to the shaft. Furrows are small circular depressions caused by the canine or cusps of molars puncturing into the bones (Haynes 1988; Holen 2006).

Plants also can leave taphonomic marks on bone in the form of root etching, which can be considered a form of chemical weathering (Johnson 2006). This modifying agent is the result of the humic acid that is released by roots. This acid in turn etches grooves in the bone in which the roots are in contact with (Schiffer 1987). Most often these grooves are highly sinuous and

irregular, following the root structure, and tend to be shallow in nature. They can be located on any outer surface of bone that is exposed. It is not determined how deep the bones need to be buried to be affected by root etching (Johnson 2006). Moreover, roots can cause damage to bone by growing through or within the bone matrix. This causes severe cracking and deterioration of the bone in the area and surrounding the root (Behrensmeyer 1978).

5.1.2 Modern Anthropogenic

Modern anthropogenic taphonomy refers to marks left on the bones due to human alteration whether intentional or by accident in a modern setting beginning at the time of initial excavation until the present. This is an important category that needs to be addressed as some modern taphonomic marks can be mistaken for butchering marks, which will be addressed in the next section. The majority of the time these marks are accidental. Archaeology, in essence, is a destructive occupation. As careful as archaeologists are trained to be, there is no predicting what will be in the sediment just below the trowel or shovel. It is, therefore, important that we are able to identify marks that were created by accident during excavations. In addition, intentional modification to artifacts may help to restore or support the fragile objects so that further degradation cannot take place. This may be in the form of glueing fragmented pieces of an artifact back together or coating an artifacts in shellac to keep them from breaking apart. This too needs to be differentiated from natural taphonomic processes and intentional modifications pre-deposition.

Accidental anthropogenic markers that appear on artifacts during excavations are one of the most common taphonomic markers found on soft surfaced artifacts. These are usually present as trowel and shovel knick marks, pen marks, or as damage resulted from dropping the artifact. Regardless of the damage, the incident should be recorded in case of the possibility of a taphonomic study to be conducted on the assemblage. In the cases where accidental marks are not recorded during excavation, the taphonomic investigator needs to be able to distinguish if the mark was caused by the excavation or by something prior to deposition.

Shovel and trowel knick marks are some of the more difficult taphonomic markers to differentiate. They exhibit characteristics that are similar to butchering cut marks on bone as these tools are usually sharp and can easily slice through a soft surface just like lithic tools. Unlike cut marks that are associated with butchering practices, shovel and trowel marks occur in random places on the bone. Butchering marks are usually found at the distal and proximal ends

of long bones near joint surfaces and usually occur in multiples (Domiguez-Rodrigo et al. 2009). Knick marks can also be distinguished by colour. Buried bone will, over time, stain darker on the outer surface due to the surrounding sediment. A fresh knick mark exposes the unstained bone below the surface and thus has a lighter colour within the gouge than the surrounding outside bone. Butchering cut marks are usually left exposed to the surrounding sediments post deposition and so will stain just like the outer surface of the bone. In addition, butchering cut marks are exposed to weathering processes over long periods of time, whereas knick marks are not. This alters the appearance of cut marks slightly by smoothing the edges of the gouge. Five trowel knick marks were identified on four separate vertebrae and the femur of the Kyle mammoth. This is not to say anything negative about the excavation work that was done in 1964, but rather to state that marks that resembled butchering cut marks on the Kyle mammoth were trowel or tool mishaps.

Intentional modifications to the Kyle mammoth were applied by the excavators in order to reinforce the bone structure. The bones were in a fragile state due to natural weathering over time. Exhuming the bones in their whole form would not have been possible without reinforcement. Shellac was added to the exterior of the bone to prevent further degradation. Shellac alone would not be able to hold the heavy bones together and so casts were created for transport and storage of the bones. Later, cement filler was added to further hold the fragmented bones together and to fill in missing fragments of bone. Although easy enough to distinguish from bone, the filler in some cases, obstructed large sections of bone from viewing. In addition, replica casts of some of the bones were created and in the process drilling holes were left in the bones of a thoracic vertebra, the mandible, and tusk. Table 5.2 summarizes both natural and modern anthropogenic taphonomic markers that were identifiable and did not occur on all of the bones (i.e. cement filler was identified on all of the bones).

5.1.3 Butchering

Cut marks, as mentioned previously, share a similar morphology with trampling marks and trowel and shovel knick marks. Cut marks, however, have very specific criteria that need to be fulfilled in order to be deemed prehistoric butchering cut marks. The trajectory of a cut mark is extremely straight with the orientation preferential to oblique and perpendicular angles to the long axis of the bone. Trampling marks in comparison are sinuous in nature with no preference

Table 5.2 Identifiable Natural Taphonomic and Modern Anthropogenic Marks

Bone	Catalogue #	Side	Natural Taphonomy	Modern Anthropogenic
Cervical Vertebra	1699.1 8810 B	-	Root Etching	Trowel knick
1st Thoracic Vertebra	1699.1 8810	-		Trowel knick
Thoracic Vertebra	1699.1 8810 C	-		
Thoracic Vertebra	1699.1 8810 Dis	-		Drill holes
Thoracic Vertebra	1699.1 8810 F	-		
Thoracic Vertebra	1699.1 8810 i	-		
Thoracic Vertebra	1699.1 8810 E	-		Trowel knick
Thoracic Vertebra	1699.1 8810 G	-	Root Etching	Trowel knick
Thoracic Vertebra	1699.1 8810 J	-		
Thoracic Vertebra	1699.1 8810 H	-		
Thoracic Vertebra	1699.1 8810 D	-		
Lumbar Vertebra	1699.1 8810 K	-		
Rib 1	1699.1 8810	Unknown		
Rib 2	1699.1 8810	Left		
Mandible	1699.1 8810	Right		Drill holes
Femur	1699.1 8810	Right		Trowel knick
Scapula	1699.1 8810	Right		
Hindfoot	1699.1 8810	Right		
Forefoot	1699.1 8810	Right		
Tusk	1699.1 8810	Unknown		
Radius	1699.1 8810 M	Right		
Ulna	1699.1 8810 L	Right		
Humerus	1699.1 8810 N	Right		

to orientation and thus the two can be distinguished, sometimes with the use of magnification (Dominguez-Rodrigo et al. 2009). The presence of barbs, the shallowing of a straight groove with a slight curve to the side, can also be indicative of a cut mark. The cross section of the groove usually presents in the shape of a V with the depth of the groove at least as deep as it is wide, if not deeper. The presence of microstriations within the grooves also needs to be present and continuous. Although microstriations can occur within the grooves of trampling marks they tend to be discontinuous due to inconsistent pressure and friction from the sediment. The shoulders of cut marks can also present shallower, parallel striae and flaking which can be indicative of the use of a retouched flake leaving a double groove with roughened shoulders (Dominguez-Rodrigo et al. 2009). These were the criteria that needed to be met in order to be determined cut marks for the Kyle mammoth.

The Kyle mammoth did not display any markers that were determined to be cut marks. This may be in part due to the poor preservation of the bones. Heavy weathering that is present on the vertebrae, scapula, and ribs may have eradicated cut marks if they were present. However, the lack of cut marks could also be due to the thickness of the joint capsule and the ease of disarticulation when the majority, but not all, of the tissue has been cut away from the joint capsule making it unnecessary to cut down to the bone. This was the theory that was presented for the Colby mammoth (Frison and Todd 1986) and the Domebo mammoth (Leonhardy and Anderson 1966) sites to explain the lack of cut marks. The lack of cut marks on the Kyle mammoth could also be due to the simple fact that there were no cut marks made on these bones. This, however, does not necessarily preclude butchering practices conducted on the Kyle mammoth as bone breaking and disarticulation was also a subsistence strategy used by Paleoindian hunters and scavengers.

Intentional bone breaking patterns caused by human modification is documented best by the work of Dr. Steven Holen at the La Sena and Lovewell sites in Nebraska and Kansas (Holen 2006, 2007; Holen and Holen 2011; Holen and May 2002). The remains of a mammoth at the La Sena site showed prominent signs of intentional bone breaking to the proximal end of both femurs. Four fragments of the cortical bone from one femur were refitted to show evidence of an impact point that measured 5 cm in diameter and a negative bulb of percussion immediately adjacent to the impact point extending into the medullary cavity. The second femur, representing the proximal end as well, was also refitted to show three separate impact points 25 cm apart. Bone flakes created from the cortical bone indicate the production of these flakes longitudinally to the axis of the limb bones. A single bone flake produced the characteristic platform with accompanying bulb of percussion and ripple marks with a hinge termination (Holen 2006; Holen and Holen 2011; Holen and May 2002). The same as lithic production, these features are indicative of percussion flaking. The most convincing evidence found at the La Sena site for bone tool production is the presence of a vertebra anvil. A single vertebra with the spinous process broken off and orientated downward into the sediment was used as an anvil for bone breaking. The upper surface of the vertebra was also heavily fragmented yet smoothed and worn as well. Immediately surrounding the anvil was a heavy concentration of spirally fractured bone (Holen 2006; Holen and Holen 2011; Holen and May 2002).

The Lovewell site also produced spirally fractured limb bones, many bone flakes, and flake scars on cortical bone. A dynamic loading point that was found on a section of cortical bone indicated that an object 3 cm in diameter was used to create the flake (Holen 2006). In addition, another piece of cortical bone showed bifacial flaking with the presence of two flake scars on one face and two longer flake scars on the other face forming a sinuous edge as is characteristic of bifacially worked lithic material. A bone fragment was also found that was determined to be a bone artifact due to the high degree of modification. It is a highly polished piece of bone that presents a snap fracture with subsequent polishing over the snap area. The identification as an artifact is due to the similarities to other artifacts, such as bone or ivory rods, belonging to the Clovis tool kit (Holen 2007). This bone artifact and the cortical bone flaking found at the site is all suggestive of human modification of this mammoth even with a lack of stone tools.

Other markers that can be indicative of butchering are related to the disarticulation of the appendicular skeleton. Pry marks are an example of disarticulation related to butchering. At the Dent site in Colorado, pry marks were observed on the femur on the articular head and on the distal end presenting as gouges and shallow cylindrical depressions, respectively (Saunders 2007). The gouge found on the articular head is indicative of the dismemberment of the hind leg from the hip joint and may have been accomplished with the use of a bone or ivory rod. Additionally, the shallow indents on the distal end show the possible use of two ivory rods for prying as one indent is flat-bottom indicating a beveled ended rod and the other is more crater-like indicating possibly the use of a pointed rod and the combination of the two indicating a cooperative activity (Saunders 2007).

The research conducted by Holen at the La Sena and Lovewell sites and the evidence of pry marks presented at the Dent site were used as a proxy for the taphonomic study on the Kyle mammoth in the search of bone breakage patterns characteristic of human modification. Unfortunately, none was found that definitively suggested human involvement. However, this may also be due to a lack of preservation as previously suggested with the lack of cut marks. Without the complete skeleton, it cannot be known for sure.

5.1.4 *Taphonomic Features of the Kyle Mammoth*

The postmortem taphonomic study revealed no definitive signs of human intervention with the Kyle mammoth. However, a couple of interesting finds were uncovered that are worth mentioning briefly in this section.

One interesting find that needs to be mentioned is a fragment of spongy bone that was uncovered in fragment box P1699.8 8810 (Figure 5.1). It contains suture lines and is rough on one surface and is extremely flat, smooth, porous, and polished on the opposing surface. It is thought to either be part of the skull or more likely part of the sternum, although the preservation of a sternum is usually seldom due to its light nature. Regardless of the preservation, the smooth, polished surface contains several extremely straight grooves, all of varying depths, widths, and slight differences in angles of orientation. Upon further magnification, the grooves were observed to be U-shaped in cross section with rounded shoulders and contained no striations on the walls or base of the groove but were rather smooth, polished, and contained funnel-like openings along the groove like the surface of the bone. After deliberations, it was concluded that the grooves were definitively not cut marks, were not caused by trampling or accidental knick marks, and were not caused by root etching. The only other possible explanation for the grooves was something vascular in nature. Upon further research it was revealed that these are in fact blood-vessel impressions (D'Errico and Villa 1997). The largest groove was interpreted to be the main artery with the other grooves the accompanying veins. The funnel-like opening along the groove's interior would be interpreted as the extending capillaries (D'Errico and Villa 1997). The sheer size of these grooves is noteworthy, but it is emphasized that this is very large mammal (over 6 tons) and blood vessels will likewise be very large.

The second interesting find was the small portion of a rib that was found in the fragment box P1699.11 8810 (Figure 5.2). It represents the proximal portion at the angle of the rib lacking the head and the body. At the distal portion of the fragment there is a hinge fracture that is orientated transversely to the long axis of the rib. The left portion of the fracture is missing. The right distal portion of the fracture is present in the centerline of the shaft and feathers out medially. This type of fracture represents a dry bone fracture that could be indicative of a number of causes. The first is the result of sediment loading. The second is from trampling although no other signs of trampling (i.e. trampling marks) could not be identified on the bone. Lastly, intentional bone breaking could also cause hinge fracturing. However, the lack of a



Figure 5.1 Spongy bone from fragment box exhibiting several straight grooves determined to be vessel impressions.



Figure 5.2 Rib fragment from box P1699.11 8810 with hinge fracture indicated by the green arrow. Inconclusive origin.

dynamic loading point on this portion of fragment cannot preclude human intervention. Unfortunately, other fragments belonging to this piece could not be found within fragment box and so a definitive cause could not be concluded.

5.2 Antemortem Modification

Reference now needs to be made to antemortem modification to the Kyle mammoth bones. During the taphonomic study concentration was heavily geared towards the postmortem and perimortem aspect of the Kyle mammoth bones as human interaction with prey usually presents in the form of traumatic unhealed wounds and butchering marks. However, a subtle modification to one of the bones required further investigation in the area of antemortem modification as no postmortem or perimortem modification could be determined to be the causing factor.

A single antemortem lesion (Figure 5.3 A) was identified on the right transverse process of the thoracic vertebra 1699.1 8810 J. It was identified as such due to the lack of any similar features present on any of the adjacent vertebrae and the lack of this feature present on the vertebra of the comparative collection. Also, the identification of this vertebra as one of the lower thoracic vertebrae in transition to the lumbar vertebrae suggested that the foramen was not associated with the transverse foramen characteristic of cervical vertebrae. The lesion tunnels the entire width of the transvers process, 15.3 mm medial-laterally and is positioned 26.5 mm posteriorly from the furthest portion of the anterior aspect of the transverse process to the anterior aspect of the lesion and 68.3 mm from the most posterior portion of the transverse process to the posterior aspect of the lesion. The shape is roughly oval and expands in all directions laterally forming a funnel shape on the right lateral side with a minimum width of 14.3 mm in the center of the ‘tunnel’ and a minimum height of 11.6 mm. The lesion is smooth along all of its borders with the exception of slight postmortem degradation presenting on the superior border. In addition, a smaller lesion, in association with larger lesion just described, is located adjacent to the medial opening of the large lesion and extends only slightly medially at a shallow oblique angle into the superior aspect of the vertebral arch (Figure 5.3 B). The opening of the smaller lesion is also oval in shape and measures 7.2 mm for the maximum width and 5.1 mm for the maximum height and terminates to a point roughly 5 mm into the cortical bone of the vertebral arch. The depth is estimated due to the unknown amount of sediment remaining within the lesion. When the two holes are viewed as a single lesion the outline is conical in shape that is

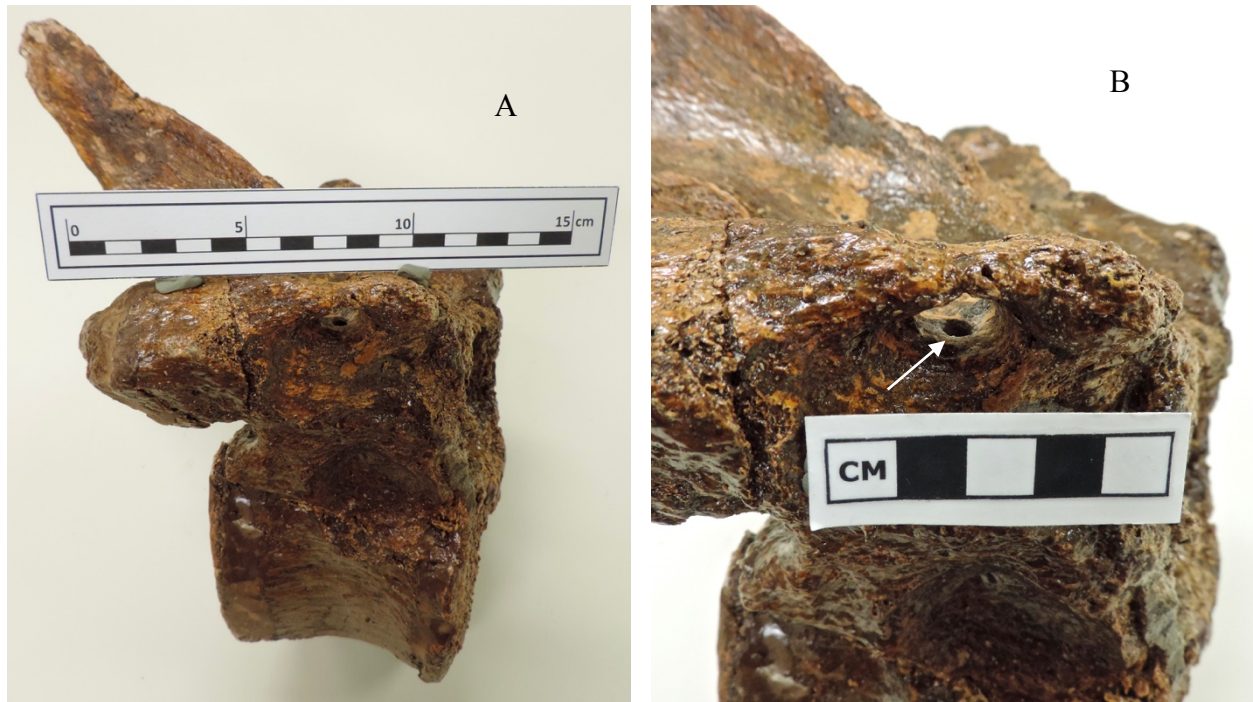


Figure 5.3 The lesion exhibited on the lower thoracic vertebra of the Kyle mammoth (1699.1 8810 J)
a) The vertebra as a whole. b) Zoomed in with smaller lesion seen through the larger as indicated by the white arrow

slightly squished superior-inferiorly with the tip of the cone positioned in the lesion of the vertebral arch and the expanded base positioned on the right lateral aspect of the transverse process.

The smooth characteristic of the walls of the lesion suggested that the bone suffered some sort of damage, whether pathological or traumatic will be discussed later, and subsequently healed before the demise of the animal. In order to confirm that the lesion had in fact healed a radiograph was produced in order to investigate the nature of the cortical bone growth surrounding the lesions. Figure 5.4 shows the X-ray image with the lesion clearly visible. The walls surrounding the lesion also clearly show the formation of cortical bone which confirms the notion that the lesion is in fact fully healed prior to the death of the Kyle mammoth. The investigation thus begins into the cause of the lesion. Some less likely causes have been suggested and investigated but two major theories have been proposed.

5.2.1 Trauma

Initially the idea was the hole represented a healed lesion resulted from antemortem trauma. Trauma is defined by any bodily injury or wound that results in the complete or partial



Figure 5.4 Radiograph of the vertebra presenting the lesion in the right transverse process. The presence of cortical bone surrounding the lesion as indicated by the green arrows indicates a healed lesion.

break of a bone, displacement or dislocation of bone from articulation, a disruption in blood or nerve supply, and the intentional deformation of shape and contouring of bone (Roberts and Manchester 2005). In the case of the Kyle mammoth the lesion would be defined as a puncture wound according to Byers (2011) definition who states: “In cross section, these injuries generally are shaped like a cone; they range from circular to somewhat oblong pits with pointed floors. The depth of the wound depends on the energy of the causative force and the nature of the

instrument.” However, contrary to the definition by Byers (2011) who also defines puncture wounds as directed vertically, the trajectory of the puncture on the Kyle mammoth would have been from the right side at an angle slightly lower than horizontal through the transverse process and terminating into the vertebral arch. In addition, the subsequent healing that took place after the modification to the bone caused by a puncture suggests that the animal survived the trauma and complete healing of the wound is evidence that the cause of death could not be from this particular lesion.

The argument could be made, from an archaeological standpoint and from the information provided above, that the wound could have been caused by a projectile point. Although not lenticular in shape as most projectile points are characterized by, the oval shape of the lesion could be explained by the process of healing. Puncture wounds may be accompanied by fracture lines or large hinge fractures if the force is great enough (Byers 2011). The depth of the lesion would suggest that the force needed in order to puncture through the transverse process and terminate in the cortical bone of the vertebral arch of a woolly mammoth is extreme. Thus fracturing caused by the initial impact and subsequent healing of, not only the puncture wound but the fractures that would accompany it, may have led to a remodeling of the original shape of the puncture wound from lenticular to more oval during the mechanical phase of bone healing. Complete closure of the wound may not have been possible due to the large amount of missing bone caused by the puncture (Roberts and Manchester 2005).

Alternatively, the puncture wound, although it did not leave a projectile imbedded, may have induced an inflammatory reaction. Polet et al. (1996) uncovered a human innominate from the Trou Rosette in Belgium with an imbedded arrowhead. The bone trauma that was created by the force of the arrowhead penetrating through the ilium and the fragment of arrowhead that was subsequently retained within the wound induced an inflammatory reaction causing a peripheral sclerotic reaction that led to the formation of a cavity surrounding the arrowhead. Due to this post traumatic reaction, not only did the initial lesion grow in size, but it also distorted the shape immensely giving the arrowhead room to move (Polet et al. 1996). The peripheral sclerotic reaction that caused the cavity in the innominate found in Belgium could also explain an expanded puncture wound caused by a projectile in the Kyle mammoth altering the shape of the initial wound from lenticular to oval.

The shape of the wound could also be explained by another weapon from the Clovis toolkit. The use of a bone or ivory rod could also be a possibility in terms of the cause of a puncture wound. These rods are cylindrical in shape and either haft a projectile point on one end acting as a foreshaft or can be sharpened to form a perishable projectile (Kornfeld et al. 2010). Figure 5.5 shows a to-scale ivory rod cast positioned within the lesion on the right transverse process. Although the wound is only slightly larger than the rod, it shows the shape and the trajectory of the lesion accommodating the idea of a wound caused by a bone or ivory rod. This is not conclusive, in the slightest, of human interaction but is only suggestive in nature.

Other objects other than projectile points can also cause a cone shaped puncture wound. Large carnivores from the late Pleistocene contemporaneous with the woolly mammoth have been known to target mammoths as prey. These carnivores possess very large canines, especially the saber-toothed cat (*Smilodon fatalis*) and the giant short-faced bear (*Arctodus simus*). It is a possibility that these Pleistocene predators may have attempted to hunt the Kyle mammoth but were unsuccessful leaving only a puncture wound in the vertebra. This possibility was considered, however, the lack of smaller lesions surrounding the one present suggest that this is not the case as other tooth marks would have made themselves present in the attempted hunt. As well, the force needed to puncture the transverse process would have to be immense as was stated previously.

5.2.2 Pathological

The second major theory that could explain the lesion on the vertebra belonging to the Kyle mammoth is based in pathology. Pathology is defined by Roberts and Manchester (2005) as the study of suffering with the study of paleopathology encompassing abnormal variations to organic remains from an archaeological site. Although trauma would be considered a group under the study of paleopathology, here the term paleopathology encompasses an internal causation for the abnormal morphology of the lesion. The difficulty in studying diseases in the archaeological record is in the acute stage of disease development that mainly targets the living tissue. Most individuals usually succumb to the disease within this stage of development (depending on the disease) before any record of its presence is able to penetrate the bone. Bones that do present morphological changes from disease are representative of chronicity (Roberts and Manchester 2005). These are individuals that are usually the strongest in the populations and



Figure 5.5 Bone/Ivory rod cast inserted into the lesion showing the possibility that a weapon may have cause the lesion on the thoracic vertebra

have survived the acute stage of the disease and responded to the disease by adaptations. These adaptations are exhibited in either bone formation and/or destruction.

The specific diagnosis of a particular disease is of far greater difficulty without the presence of soft tissue. In addition, multiple diseases may cause the same bony response as reaction to stimulus in bone can only present in a limited number of ways. All diagnostic possibilities must be considered upon initial evaluation of the lesion or lesions and rejected as a diagnosis through the process of elimination when further examination of the skeleton and other factors such as dispersal are taken into consideration (Roberts and Manchester 2005). The lack of a complete skeleton proves even further difficulty in a specific diagnosis as the extent of the disease would be unknown. For many diseases that affect particular areas of the skeleton the lack of a complete skeleton means a specific diagnosis would not be obtainable (Roberts and Manchester 2005). For the Kyle mammoth, the diagnosis of a particular disease cannot be obtained due to the lack of a complete skeleton. Thus a number of diseases may be the cause of the lesion (including the traumatic puncture wound) with the more likely explanation given here.

Bone pathologies in woolly mammoths, although noted in some skeletons, are rarely researched or described in the literature as focus on the extinct mammal is usually in human interaction. Although this line of inquiry may explain the demise of some mammoths, others may have died of natural causes including by diseases and thus further description and research needs to be conducted on pathologies found in mammoths. This is also easier said than done as the lack of any living mammoths today and the preservation of skeletons lasting until modern times does present difficulties. However, Krzeminska et al. (2015) studied 625 thoracic and lumbar vertebrae belonging to woolly mammoths (*Mammuthus primigenius*) from Eurasia from the time period between 27 to 23 ka BP of which 329 presented what was termed as ‘hollows’ or ‘holes’ from osteolytic changes to the spinous process. From this study, osteolytic changes were recorded in visual stages or classes of severity ranging from small piercings (Class II) to large lesions tunneling through the spinous process (Class VII) representing developmental stages of bone loss through a negative balance between bone formation and remodeling and bone absorption (Krzeminska et al. 2015). The lesions are usually located on the thoracic vertebrae, on the caudal portion of the spinous process at the proximal end closer to the vertebral arch but superior to the inferior articular processes. They never, however extensive the lesion, sever the process from the vertebral arch if the lesion has reached class VII. These lesions can also be seen, although rarely, along the center axis of the spinous process on the cranial side, below the inferior articular process, the distal end of the spinous process, or on the lumbar vertebrae (Krzeminska et al. 2015).

The lesions studied by Krzeminska et al. (2015) showed varying stages of destruction all the way to stages of healing. The majority of the lesions studied represented osteolytic bone absorption with characteristic rough, porous bone at the point of the lesions. Lesions that were healing or healed were primarily restricted to the first several thoracic vertebrae of the spinal column where large muscle attachments aided in the healing process of the bone through the constant application of mechanical force after the termination of bone absorption (Krzeminska et al. 2015). X-rays that were taken of 23 spinous processes in varying stages of destruction revealed that bone density was reduced in spinous processes classified into class III or greater. Some of the spinous processes that were classified into class I (no visible osteolytic changes) also showed reduced density indicating that ongoing osteolytic changes have not yet been made visible but are present. Krzeminska et al. (2015) suggest that the formation of the lesions seen in

the spinous process is due to the reduction first in mineral density within the bone that leads to the deterioration of the microstructure of the bone and subsequent absorption and remodeling of the bone to form the lesions that range in severity before healing begins to take place. The suggestive cause of the initiating reduced bone density is a metabolic disorder specifically in phosphate and calcium. Malnutrition and vitamin and mineral deficiency in a single animal would have responded by stimulating osteoclastic reabsorption and laying down unstructured woven bone lowering the bone density and eventually forming visible lesions (Krzeminska et al. 2015).

Malnutrition causing the disruption of calcium and phosphate metabolism could be an explanation for the appearance of an osteolytic lesion on the transverse process of a thoracic vertebra from the Kyle mammoth. Although the placement of the lesion is not the same as the characteristic positioning of lesions on the caudal surface of the spinous process as presented by Krzeminska et al. (2015), the vertebra from the Kyle mammoth does show three other osteolytic lesions on the same thoracic vertebra as the lesion described above (P1699.1 8810 J). The first osteolytic lesion (other than the major lesion on the right transverse process of the same vertebra) is located on the left transverse process on the very posterior aspect along the left lateral margin and inferior margin spanning 18.3 mm across and to a height of 14.4 mm (Figure 5.6). It is characterized by a cluster of 5 shallow depressions indicating that osteoclastic absorption was occurring at the time of death. The second osteolytic lesion (Figure 5.7) is located on the right facet of the inferior articular process. It is positioned centrally at the most anterior aspect of the facet and has two adjacent shallow depressions that span 10.1 mm by 6.3 mm. The last lesion (Figure 5.8) is located on the very tip of the spinous process on the central axis of caudal surface. It is described as a single shallow depression that is oval in shape and spans 6.8 mm in width and 12.4 mm in height. No other bone from the Kyle mammoth presents these lesions, although deterioration of the bone may have obliterated any evidence if they were present. Although the only lesion that fits the characteristic osteolytic lesions observed by Krzeminska et al. (2015) is the last lesion just described due to its location on the spinous process, the other lesions do fit the characterization of a metabolic disorder causing osteolytic lesions through bone absorption. In addition, the physiological profile of the Kyle mammoth representing a fairly young male can be a contributing factor in the presence of malnutrition.



Figure 5.6 Osteolytic lesion on the left transverse process on the posterior aspect. Indicated by the white arrow.



Figure 5.7 Osteolytic lesion on the right facet of the interior articular process. Indicated by the white arrow.



Figure 5.8 Osteolytic lesion on the central axis of the spinous process on the caudal surface. Indicated by the white arrow.

African elephant groups as studied by Haynes (1991) expel the males from the matriarchal herd right after maturity around the age of twelve. They are then required to learn how to feed and water themselves, making the first couple years after maturity difficult in terms of nutrition. Male elephants become extremely competitive and aggressive in this fashion. Young males who have yet to reach full mass may experience the losing end of older male aggression and thus may not get the chance to acquire the nutrition needed for a proper working metabolism during the younger years of their lives. The Kyle mammoth in the same way may have been experiencing malnutrition due to competition with larger males.

Alternatively, malnutrition may have been caused by a changing climate. As described in Chapter 3 a drying period that characterizes the end of the Late Pleistocene may have put stress on the Kyle mammoth to find proper nutrition. The added competitive nature of other males also suffering from malnutrition would have exacerbated the situation until bone modifications took place. Subsequent improved nutrition would have stimulated healing in the large lesion. Another bout of decreased nutrition may have begun the absorption process again this time in three separate locations on the vertebra from the previous area and remained until the time of death.

Krzeminska et al. (2015) attributes the cause of bone absorption within malnutrition, but further attributes renal osteodystrophy as the main cause of bone absorption within mammoth vertebrae. Any nutrient disruption in renal excretory and endocrine activity disrupts metabolic stabilization within the system, in this case specifically calcium and phosphate deficiencies. Bone resorption can occur at many rates from high to low depending on the severity of the malnutrition forming, in some instances, erosive cavities like the ones seen in Eurasia (Krzeminska et al. 2015) and on the Kyle mammoth. Further support is given to a metabolic disorder in the form of bone healing. A correction in nutrient absorption such as an improved change in diet begins the process of bone formation and healing (Krzeminska et al. 2015).

5.3 Summary

The bones of the Kyle mammoth were recovered in a poor state of preservation. Heavy weathering was recorded on most of the bones with an average stage of weathering of three. The position of the bones when initially exposed at the surface was recorded, but due to the dynamic landscape that would have been present at the time (hummocky moraine overtop stagnant ice), the distribution of the bones would not have presented any crucial information other than to state the constant changing of the landscape during glacial retreat.

Although the taphonomic study did not reveal any evidence of human alteration to the bones in terms of butchering practices, the investigation proved to be successful in the simple application of a taphonomic study to prove or disprove the use of the Kyle mammoth for Paleoindian subsistence. Moreover, the addition of an antemortem pathological study could still suggest a possible link to human-mammoth interaction. The presence of a healed lesion on the transverse process of a thoracic vertebra led to an investigation into the cause of the lesion. Trauma was suggested as a possible cause for the lesion in the form of a puncture wound. Any number of hard implements can be used to cause a puncture wound from stone tools created by humans to natural megafauna predators of the Late Pleistocene. In contrast, the lesion could have also been caused by any number of stimulants causing an osteoclastic reaction in the transverse process. A metabolic disorder was suggested originating in malnutrition and was supported by the addition of three other lesions located on the same vertebra. However, the initial lesion represents a separate reaction, probably to an earlier episode with a lack of nutrition causing osteolytic changes and subsequent healing and the three additional lesions represent a second bout with malnutrition but represent a stage of decrease bone density and osteoclastic absorption.

Chapter 6

Conclusion

The Kyle mammoth project was intended to draw attention to the lack of Quaternary research regarding the relationship between Paleoindian people and proboscidean procurement in Saskatchewan through a taphonomic study and to supplement research already being conducted in this field. The investigation proposed two questions to be answered by the end of the project: (1) Is there a possible Clovis and proboscidean association on the northern Great Plains, and (2) Can an applied taphonomic study determine if any of the identified taphonomic markers on the remains be evidence of human procurement strategies? Using a multidisciplinary approach of research, an environmental and characteristic profile was presented in order to establish a context prior to the demise of the mammoth. The taphonomic study encompassed all aspects of a postmortem analysis including biotic and abiotic agents, but also included the search for butchering strategies possibly utilized by Paleoindian people on the Kyle mammoth bones. An unexpected antemortem study was subsequently added upon the discovery of a healed lesion found on a thoracic vertebra. In addition, a historical background of the salvage excavation that was conducted in Kyle to recover the mammoth was also given. Together, these aspects make up the Kyle mammoth project that was presented in this thesis.

The historical excavation that was conducted in 1964 just west of Kyle, Saskatchewan drew a lot of interest from the locals all over the district and both paleontologists and archaeologist from the Natural History Museum (now the Royal Saskatchewan Museum) in Regina. The excavation first and foremost concentrated on recovering the fragile bones in complete pieces. Although screening was not conducted during the excavation, excavators searched for any evidence of human involvement in the form of discarded stone tools or lithic material. None was ever found. A radiocarbon date of $12,000 \pm 200$ years BP that was obtained in 1964 by the Department of Chemistry at the University of Saskatchewan suggests that a

possible human and mammoth interaction could have been possible. Thus began the search for any taphonomic markers that would indicated human intervention.

A field excursion out to the original site was intended to supplement the taphonomic analysis by giving a geological history of the area and introduce depositional factors that may relate to the formation of taphonomic markers on the bones. The trench profile revealed a depositional history that confirmed what Dr. Earl Christiansen had interpreted in 1964 during the initial salvage excavation. The area surrounding Kyle was first uncovered by glacial ice roughly 11 ka and the subsequent environment would have been a hummocky landscape underlain by stagnant glacial ice. The Kyle mammoth died within a kettle pond within a heavily undulating hummocky landscape and subsequent inundation by glacial Lake Stewart Valley brought in large amounts of glacial lacustrine sediments which were deposited overtop of the skeletal remains burying them for twelve thousand years. After the drainage of glacial Lake Stewart Valley, the landscape would have been exposed to surficial weathering until the remains were finally uncovered in 1964.

The osteological analysis conducted on the Kyle mammoth presented the identification of 62 elements which included phalanges and sesamoid bones and four important physiognomies about its character. Appendix A gives a more descriptive summary of each element with accompanying photographs. Two articulated feet make up the majority (2/3rds) of the identifiable elements and are described in Appendix A in their articulated form. The sex of the Kyle mammoth was determined using the size of the tusk which revealed that the Kyle mammoth was a male. The combination of epiphyseal fusion and molar eruption determined the age of the Kyle mammoth at death. Although crucial elements of the Kyle mammoth were missing in Lister's (1999) sequence of epiphyseal ossification the presence of a fully fused distal humerus and unfused proximal and distal femur gave an age roughly in the late 20's. However, molar eruption aged the mammoth to the mid-thirties. Given flexibility for individual variation the final age range given for the Kyle mammoth at death was between 28 and 35 years of age. This age range also takes into account variation among species given that comparison needs to be made to modern elephants as the genus *Mammuthus* is extinct. The taxonomy of the Kyle mammoth was determined using radiometrics from the eruption molar. When compared to Maglio's (1973) compiled study differentiating species of the family *Elephantidae* the results presented suggest that the Kyle mammoth belongs to the species *Mammuthus primigenius*.

Lastly, a new study published by Larramendi (2015) presents ratios of individual elements of woolly mammoths to the shoulder height of the animal. The most complete element of the Kyle mammoth is the scapula which revealed, using Larramendi's (2015) presented ratios, that the Kyle mammoth stood 328.66 cm at the shoulders at the time of its death. Since this was not a fully ossified element, it suggests that the animal was still growing at the time of its death.

The taphonomic analysis was subdivided into postmortem and antemortem sections. The postmortem section was then further divided into natural, modern anthropogenic, and butchering categories to account for the different taphonomic markers that were present on the bones of the Kyle mammoth. Every bone was also given a stage of weathering that determined the position of deposition for each bone. The postmortem taphonomic analysis did not reveal any taphonomic markers relating to butchering practices by Paleoindian people. The antemortem taphonomic analysis, however, did produce a healed lesion located on the transverse process of a thoracic vertebrae. An X-ray confirmed the presence of cortical bone which indicated that the lesion was fully healed at the time of death. A secondary lesion located in the vertebral arch of the thoracic vertebra adjacent to the larger lesion on the transverse process indicated that the two lesions are related.

Causes for the appearance of the lesions were suggested to be either traumatic, an exterior force causing a puncture wound, or pathological in nature caused by an internal imbalance in metabolism. A puncture wound could be caused by a number of exterior factors including Paleoindian projectile points. Clovis toolkits were meant to withstand an extreme amount of force even sometimes surviving impact with bone. The Clovis spear point or bone/ivory rod may have caused the initial wound. Subsequent healing of the wound may have altered the original shape from lanceolate to oval due to an inflammatory reaction with subsequent peripheral sclerotic reaction within the bone. The other suggested cause of the lesions was a metabolic disorder originating in renal osteodystrophy caused by malnutrition specifically the lack of sufficient calcium and phosphorus in the diet. This is the probable cause for the initial lesion as three other lesions located on the same vertebra show signs of bone absorption. However, the initial healed lesions would represent a separate bout with malnutrition and the three other lesions represent a second stint with malnutrition around the time of death. The incompleteness of the skeleton creates the difficulty in diagnosis of the lesions. A suggested line of inquiry would be to examine the bone density of the vertebra surrounding the three

lesions in the stage of bone absorption. This may indicate the health of the animal at the time of death but unfortunately may not explain the origins of the healed lesions. Krzeminska et al. (2015) also does not address the occurrence of these lesions in the specific region of the spinous process. The short explanation given for this phenomena was the “regular body’s response to the stress factor” (Krzeminska et al. 2015:183). This is also a line of inquiry that should be addressed especially in pathological analysis.

The Kyle Mammoth Project was a taphonomic analysis with roots in archaeology. The suggested interaction with Paleoindian people as an antemortem taphonomic explanation for the appearance of a healed lesion on the thoracic vertebra is not the best explanation for its appearance. The 14 sites that were listed in Chapter 2 with confirmed Clovis and mammoth association show obvious signs of the interaction between the two groups in the form of butchering marks and stone tools. Sites like La Sena (Holen 2006, 2007) with the lack of obvious human presence in the form of stone tools need to be looked at more in depth as evidence of humans may be miniscule in nature or nonexistent altogether but may be present in the form of butchering techniques utilized. Regardless of the presence of stone tools at sites containing mammoths, procurement strategies are an important aspect in the research of the first people in North America as strategies evolve based on the food stuffs being hunted and technology available for butchering.

As for the Kyle mammoth, the evidence for human association is nonexistent as the lesion was proven to be pathological in nature. The initial interpretation during the study as a traumatic lesion was suggested without the knowledge of the research being conducted in Eurasia by Krzeminska et al. (2015). Upon discovery of this research it was concluded that the lesion was in fact pathological in nature due to the similarities to the findings by Krzeminska et al. (2015) and the lesions found on the thoracic vertebra of the Kyle mammoth. The significance of a $12,000 \pm 200$ BP radiocarbon date would signify the ending of the Last Glacial Maximum and a changing in climate. This could attribute to the malnutrition that may be present at the time of the death of the Kyle mammoth and may have even lead to its death. This revelation would support the theory of extinction due to climate change and not overkill by Paleoindian hunters. This line of research is out of the scope of this thesis and would be suggested for another thesis or dissertation.

Appendix A



Kyle, Saskatchewan

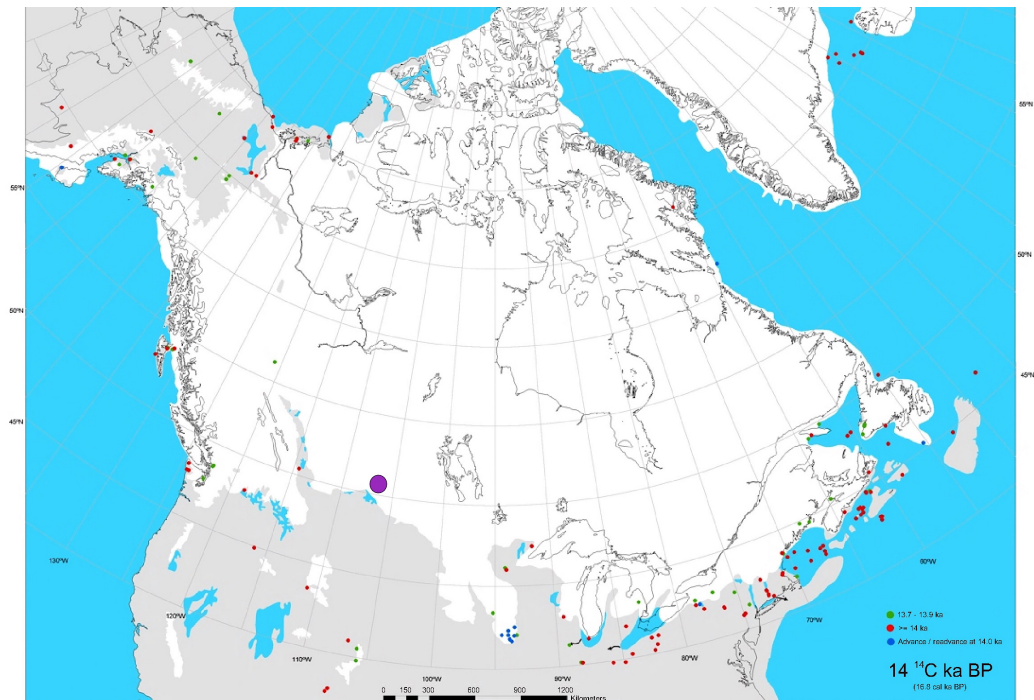


Figure A.1 Deglaciation Outline: 14 ka BP (Dyke et al. 2003).

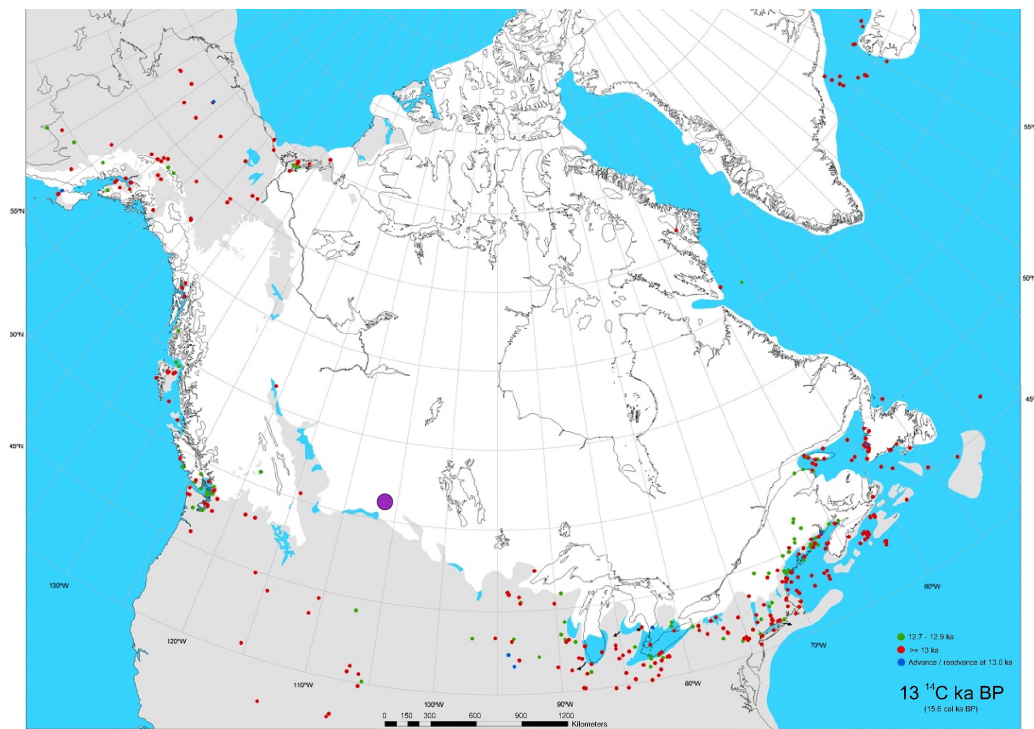


Figure A.2 Deglaciation Outline: 13 ka BP (Dyke et al. 2003).

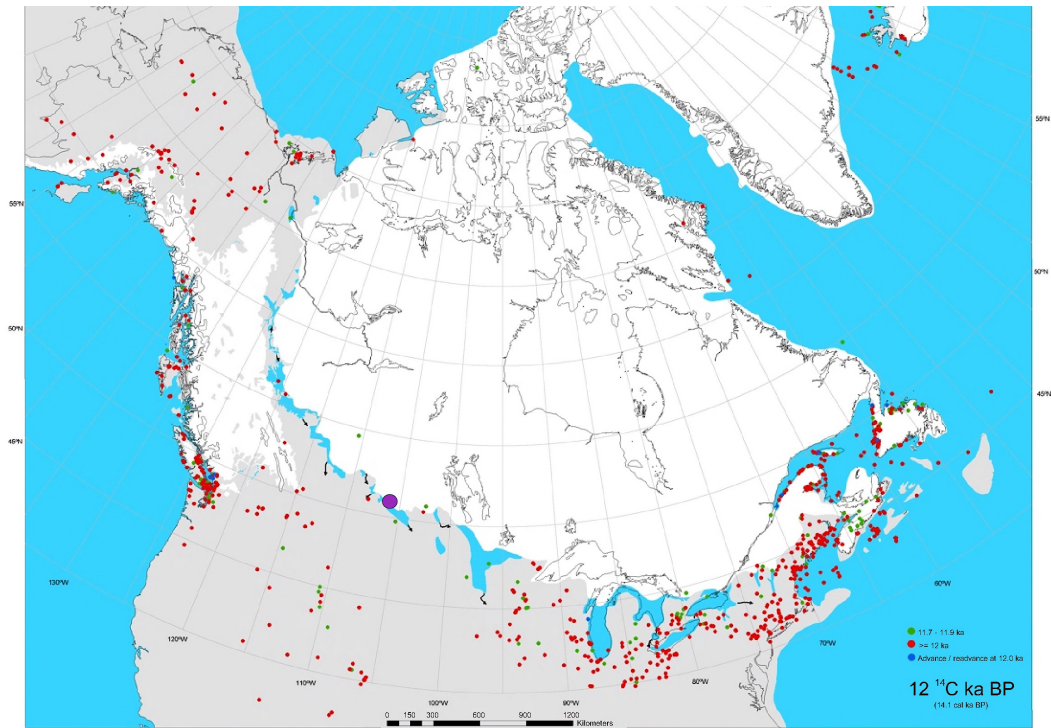


Figure A.3 Deglaciation Outline: 12 ka BP (Dyke et al. 2003).

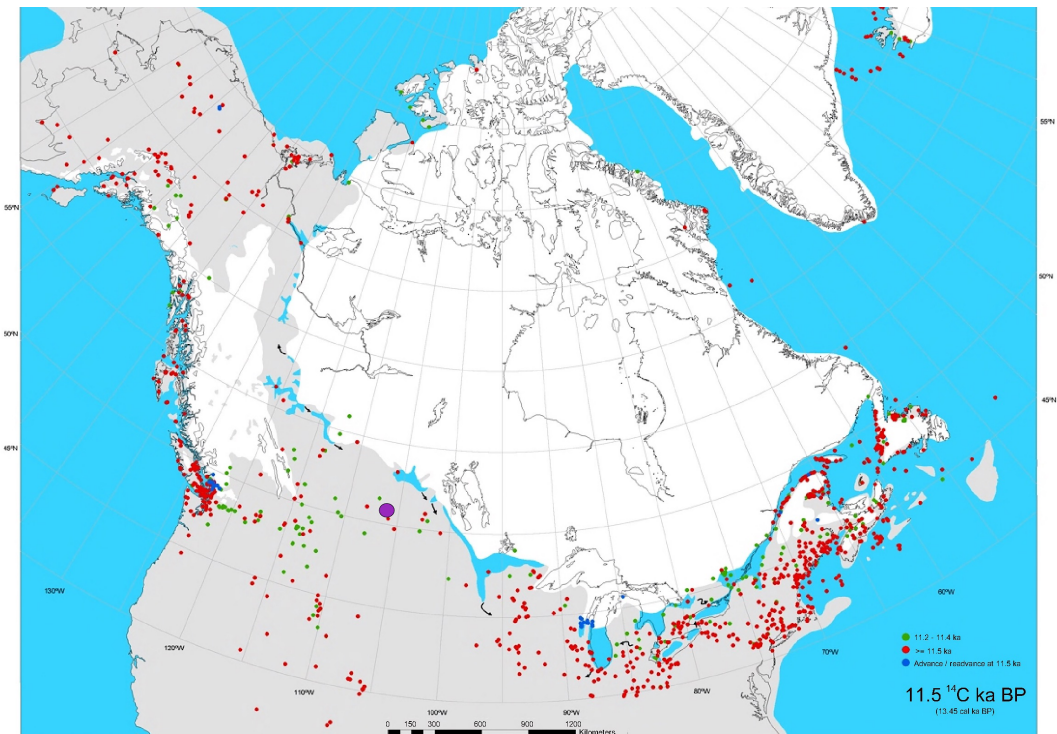


Figure A.4 Deglaciation Outline: 11.5 ka BP (Dyke et al. 2003).

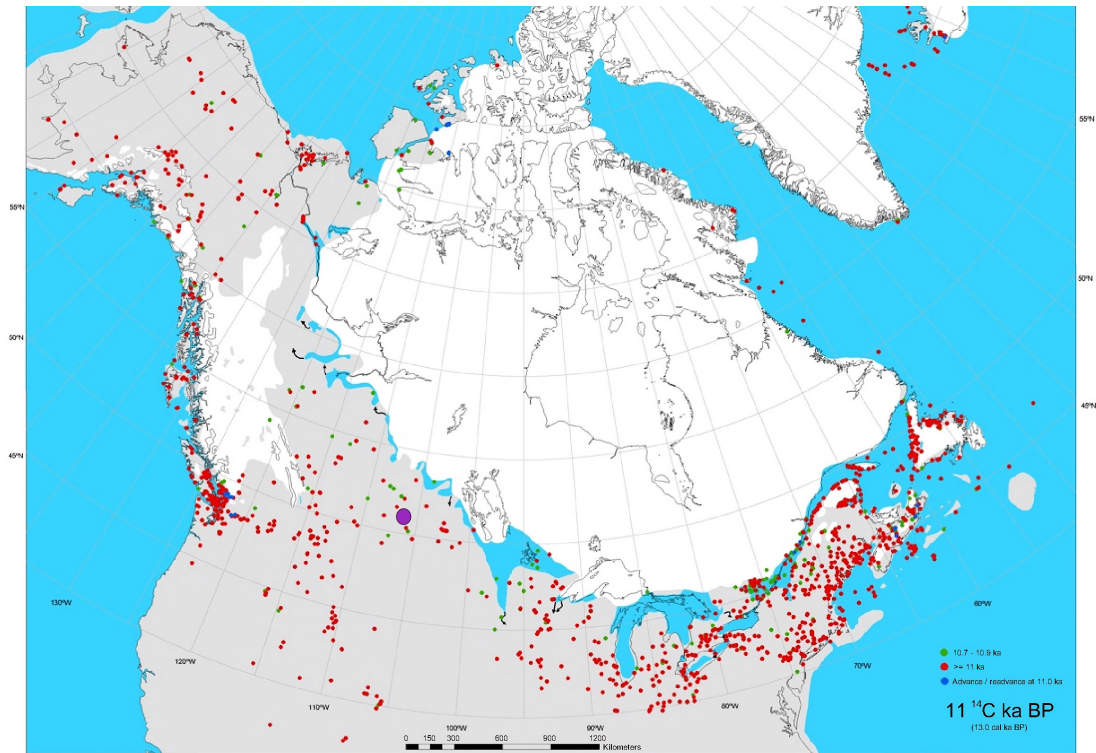


Figure A.5 Deglaciation Outline: 11 ka BP (Dyke et al. 2003).

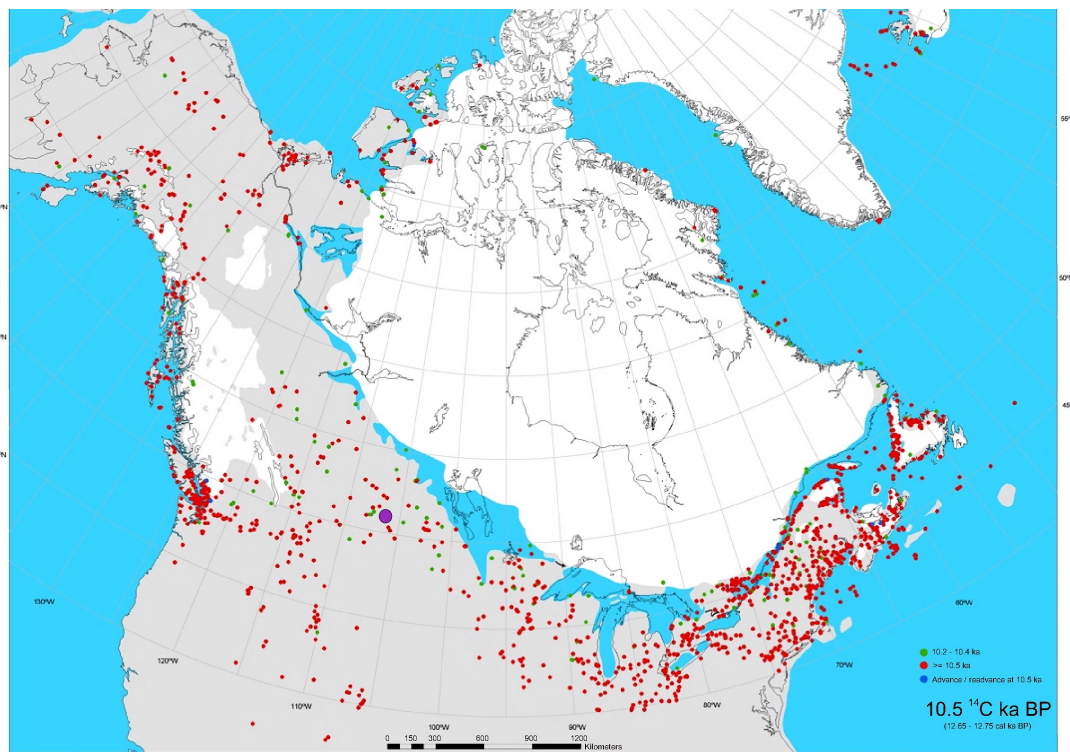


Figure A.6 Deglaciation Outline: 10.5 ka BP (Dyke et al. 2003).

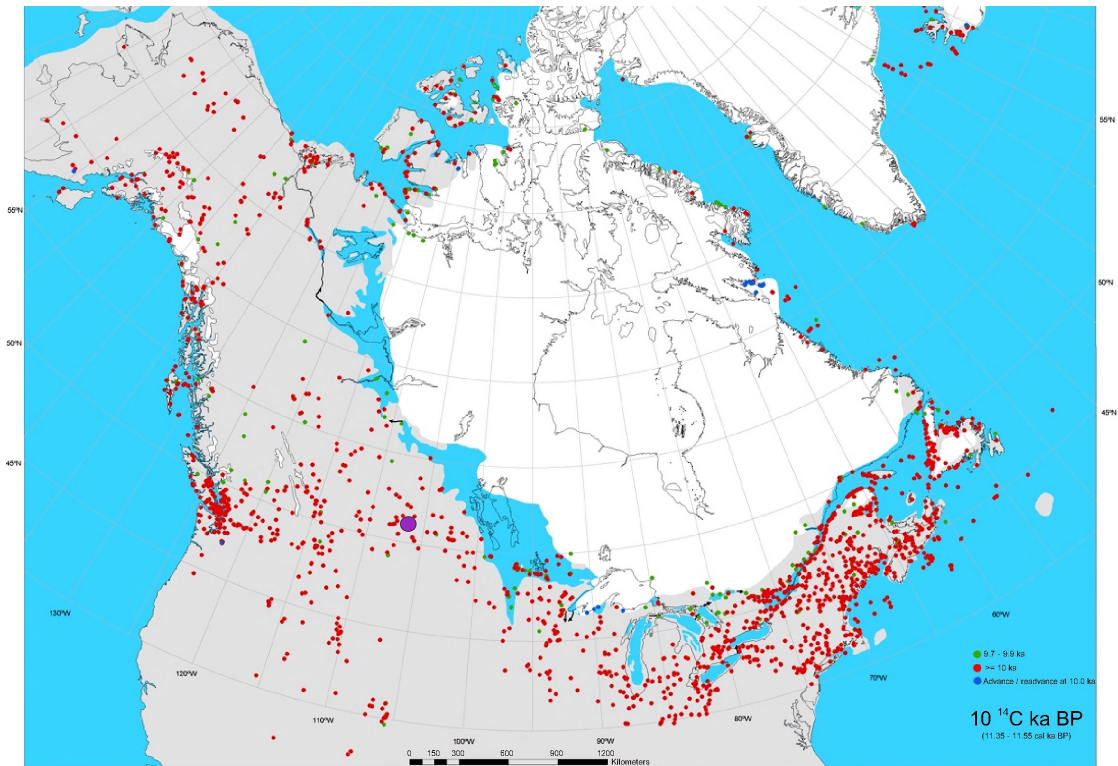


Figure A.7 Deglaciation Outline: 10 ka BP (Dyke et al. 2003).

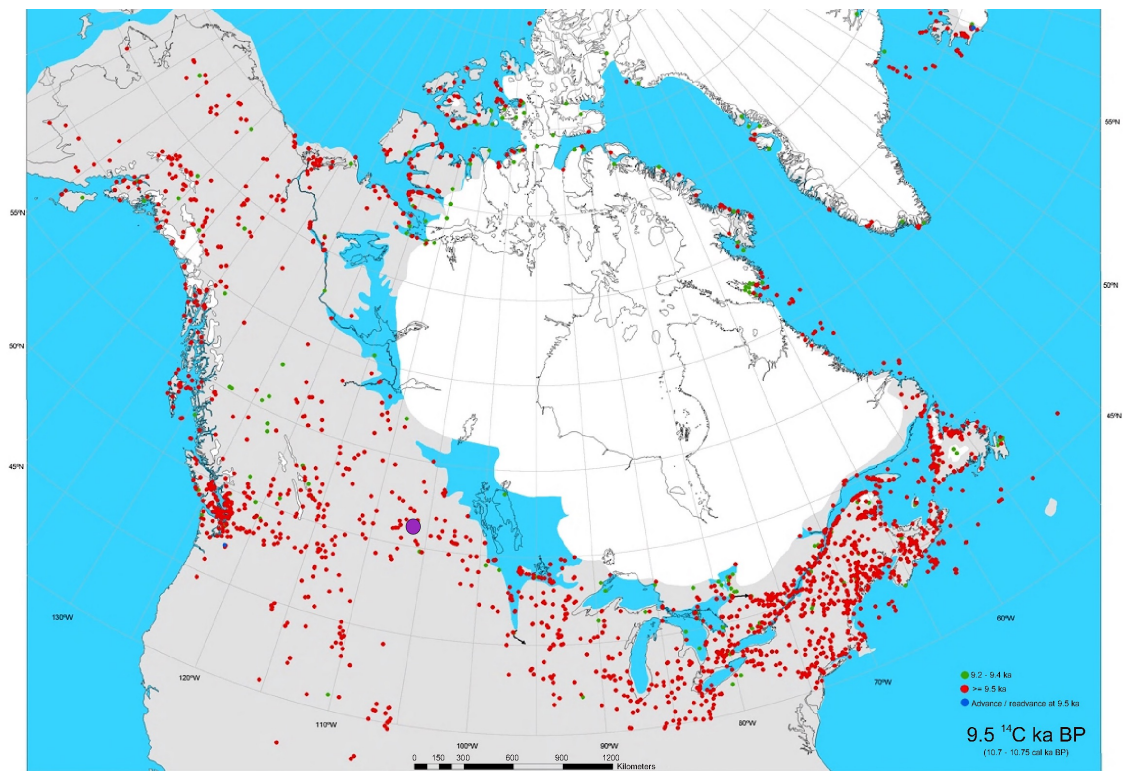


Figure A.8 Deglaciation Outline: 9.5 ka BP (Dyke et al. 2003).

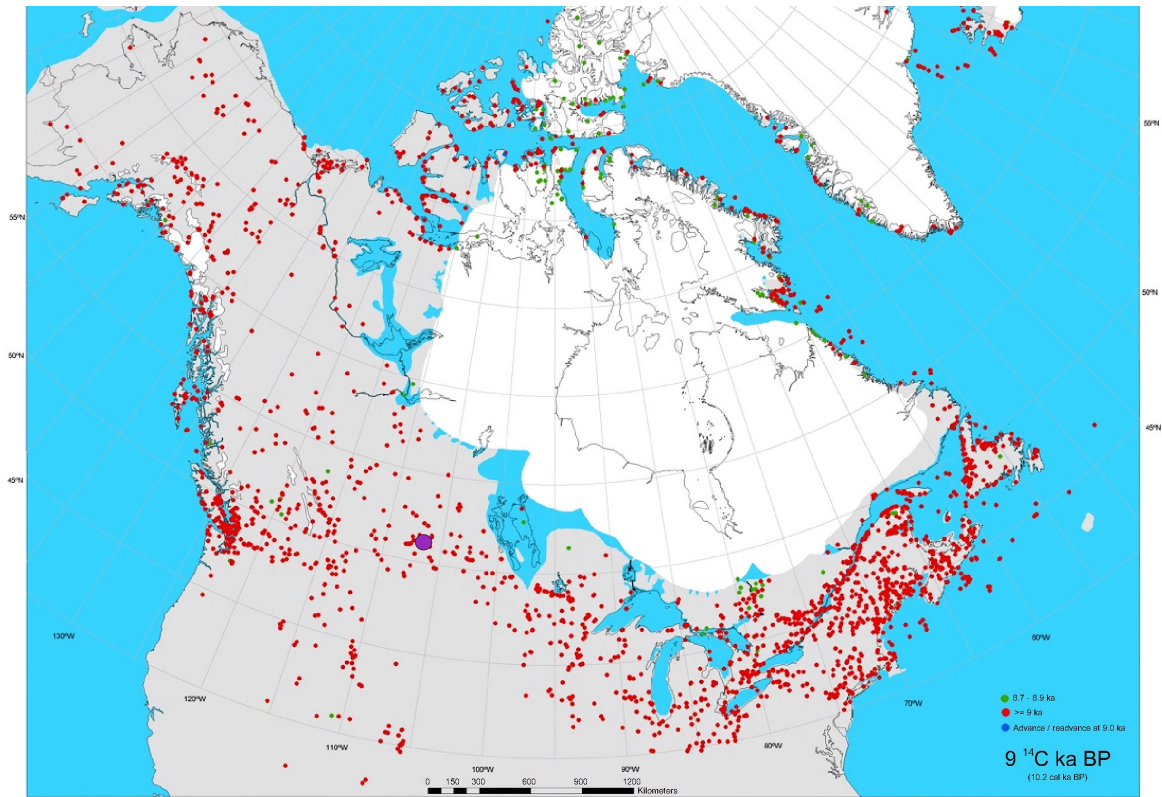


Figure A.9 Deglaciation Outline: 9 ka BP (Dyke et al. 2003).

Appendix B

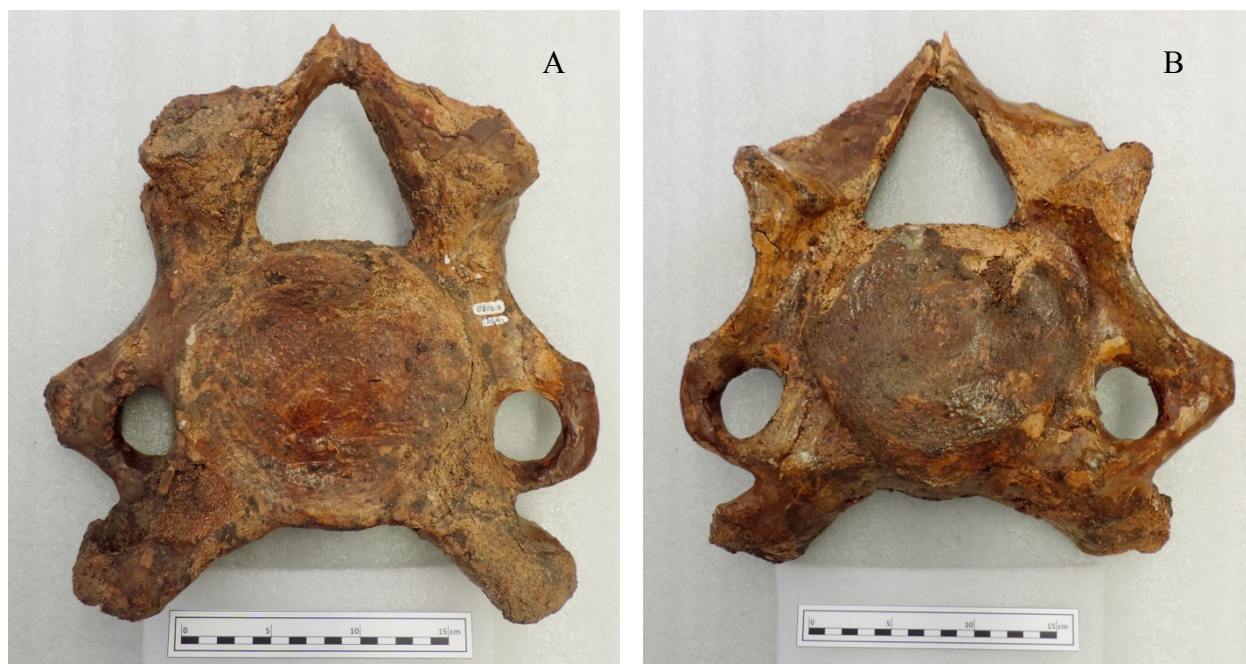


Figure B.1 Posterior (A) and anterior (B) view of cervical vertebra P1699.1 8810 B

Table B.1 Landmark Measurements for P 1699.1 8810 B

Landmark Locations	Measurements (mm)
BFcr	177.91
HFcr	168.59
BFcd	179.8
HFcd	163.8
BPtr	327.7
H	337.1 (i)
BPacr	241.07
GLPa	89.24
BPacd	229.04
PL	42.64

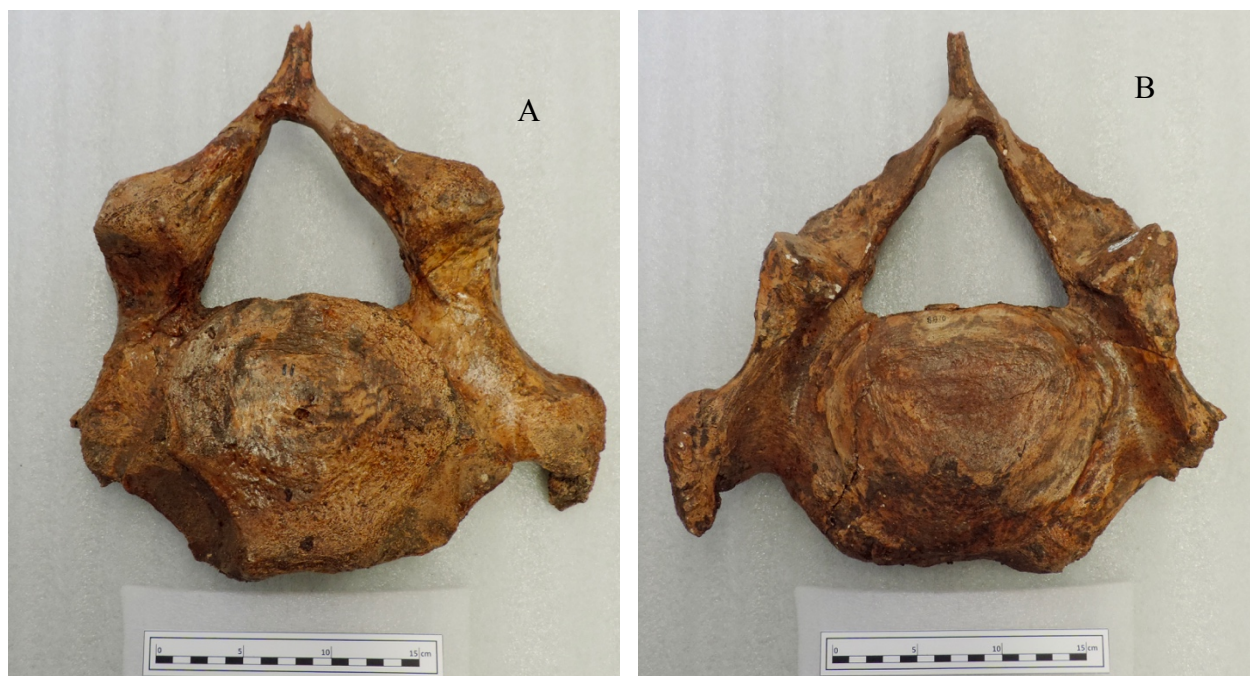


Figure B.2 Posterior (A) and anterior (B) view of thoracic vertebra P1699.1 8810.

Table B.2 Landmark Measurements for P 1699.1 8810

Landmark Locations	Measurements (mm)
BFcr	192.91
HFcr	165.32
BFcd	214.97
HFcd	164.44
BPtr	329.5 (i)
H	336.5 (i)
PL	44.97



Figure B.3 Posterior (A) and anterior (B) view of thoracic vertebra P1699.1 8810 C

Table B.3 Landmark Measurements for 1699.1 8810 C

Landmark Locations	Measurements (mm)
BFcr	176.73
HFcr	145.24
BFcd	215.39
HFcd	139.95 (i)
BPtr	366.65
H	577.95
PL	52.55

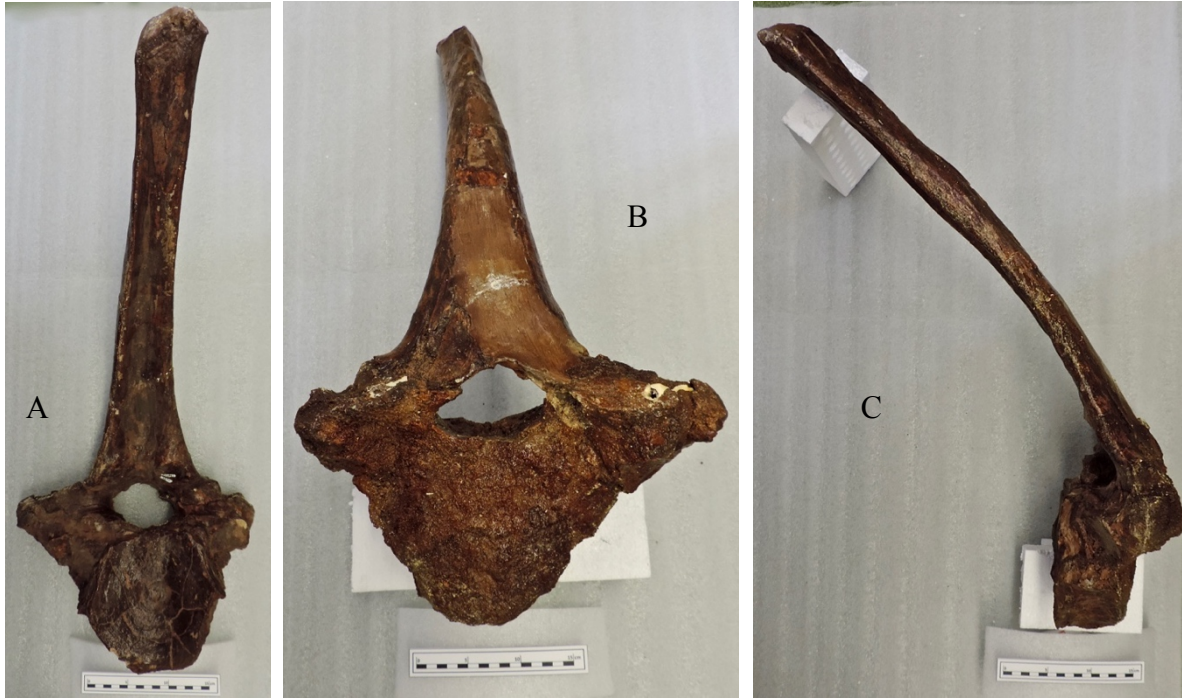
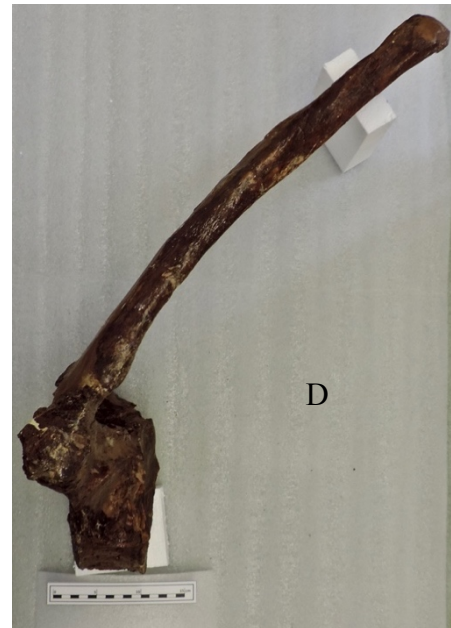


Figure B.4 Posterior (A), anterior (B) and lateral (C,D) views of thoracic vertebra P1699.1 8810 Display

Table B.4 Landmark Measurements for P 1699.1 8810 Display

Landmark Locations	Measurements (mm)
BFcr	258.69
HFcr	146.86
BFcd	249.5
HFcd	153.57
BPtr	312.65
H	559
PL	69.5



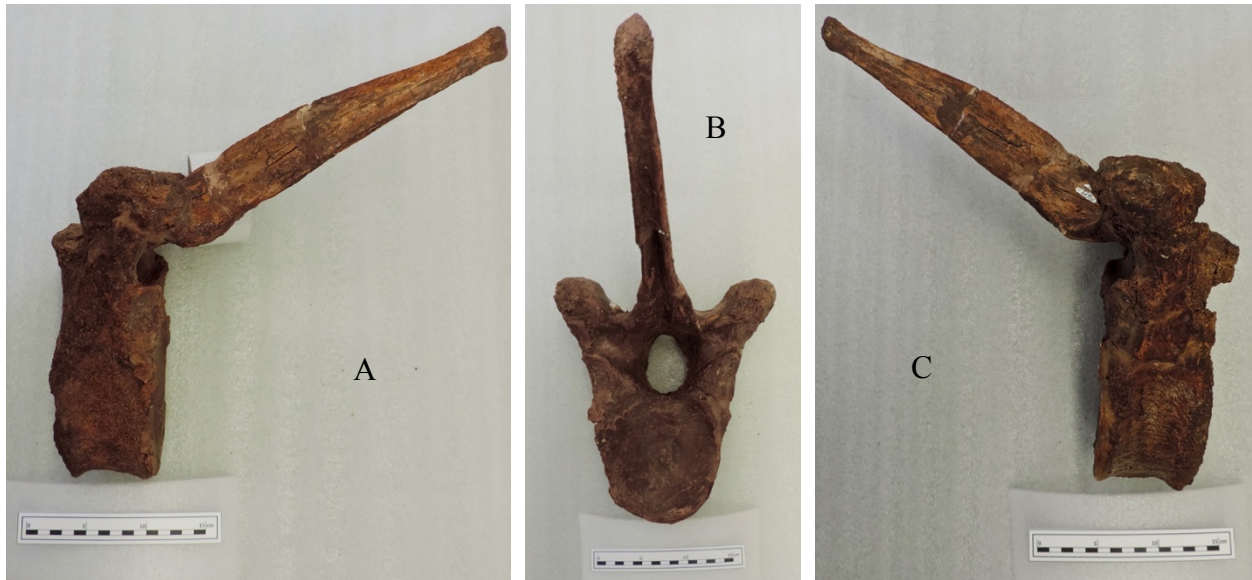


Figure B.5 Lateral (A,C), posterior (B), and anterior (D) views of thoracic vertebra P1699.1 8810 F.

Table B.5 Landmark Measurements for P 1699.1 8810 F

Landmark Locations	Measurements (mm)
BFcr	151.27
HFcr	130.03
BFcd	172.02
HFcd	129.88
BPtr	234.48
H	344
PL	75.43



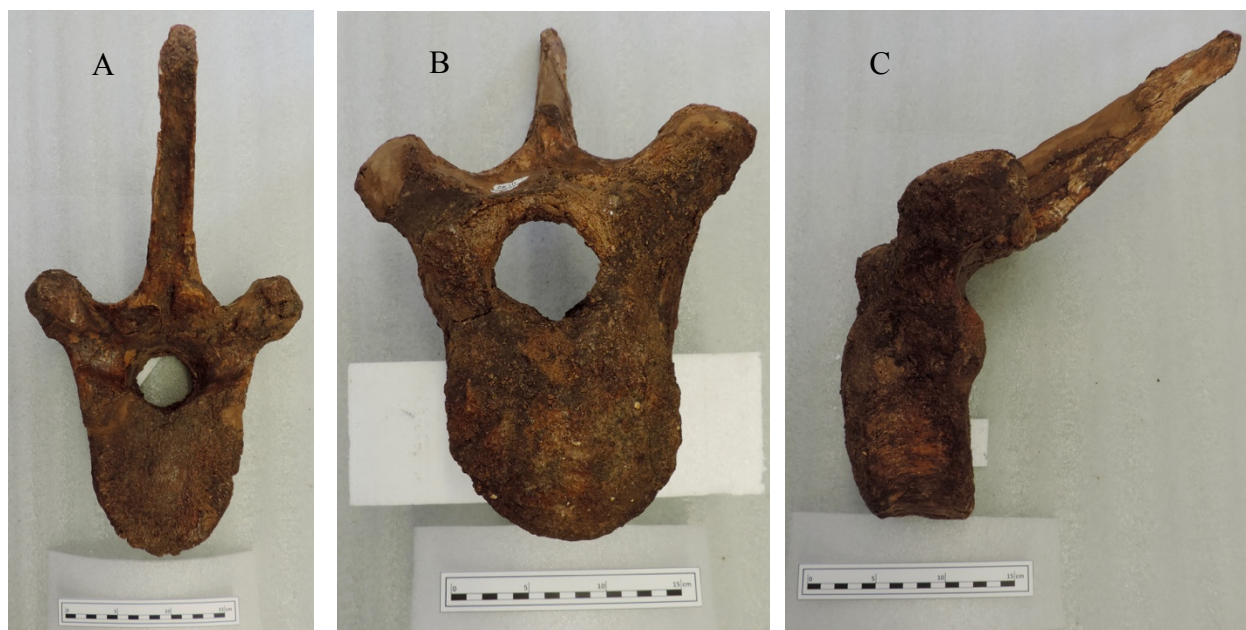


Figure B.6 Posterior (A), anterior (B) and lateral (C,D) views of thoracic vertebra P1699.1 8810 I

Table B.6 Landmark Measurements for P 1699.1 8810 I

Landmark Locations	Measurements (mm)
BFcr	121.44 (i)
HFcr	121.22
BFcd	153.09
HFcd	118.57
BPtr	141.14
H	249 (i)
PL	79.23



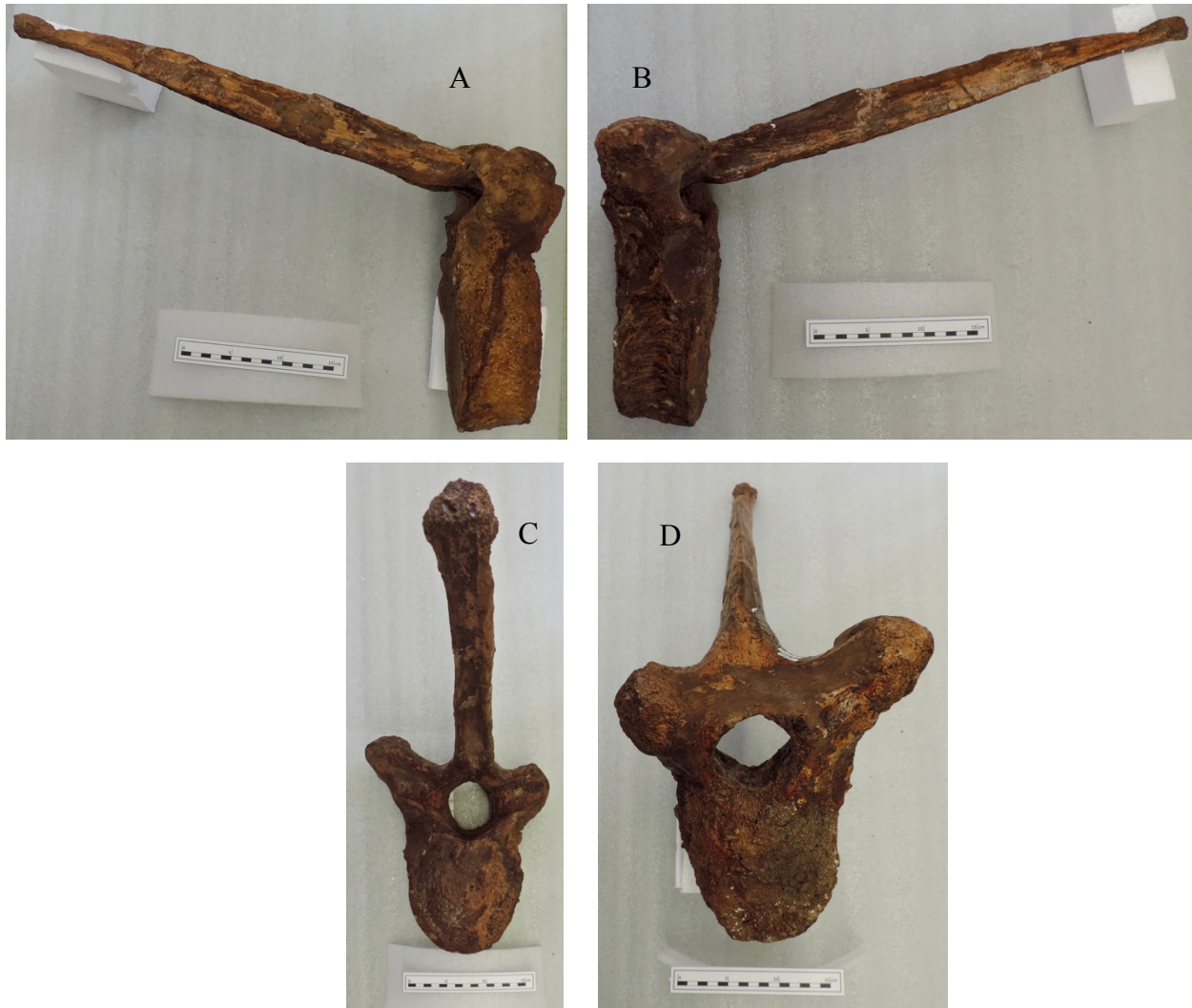


Figure B.7 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 E

Table B.7 Landmark Measurements for P 1699.1 8810 E

Landmark Locations	Measurements (mm)
BFcr	145.8 (i)
HFcr	139.87
BFcd	172.61
HFcd	142.56
BPtr	238.32 (i)
H	149.5
PL	66

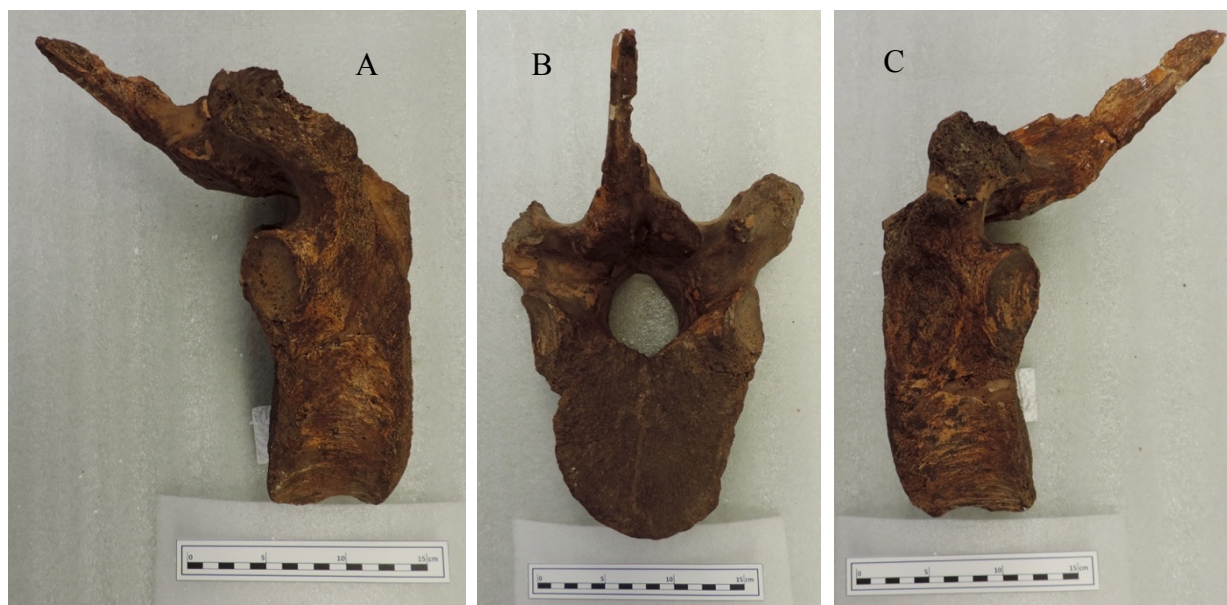


Figure B.8 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 G

Table B.8 Landmark Measurements for P 1699.1 8810 G

Landmark Locations	Measurements (mm)
BFcr	153.26
HFcr	117.28
BFcd	162.26
HFcd	120.3
BPtr	213.05 (i)
H	283 (i)
PL	76.78





Figure B.9 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 J.

Table B.9 Landmark Measurements for P 1699.1 8810 J

Landmark Locations	Measurements (mm)
BFcr	132.21
HFcr	124.92
BFcd	138.16
HFcd	136.25
BPtr	245.74
H	296 (i)
PL	76.24





Figure B.10 Lateral (A,B), posterior (C) and anterior (D) views of thoracic vertebra P1699.1 8810 H.

Table B.10 Landmark Measurements for P 1699.1 8810 H

Landmark Locations	Measurements (mm)
BFcr	129.7
HFcr	127.61
BFcd	124.73
HFcd	135.69
BPtr	237.5 (i)
H	279 (i)
PL	82.46

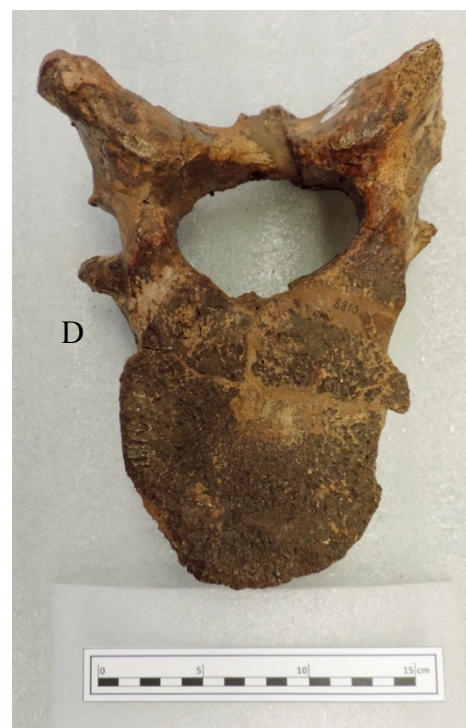




Figure B.11 Lateral (A,B), posterior (C) and anterior (D) views of lumbar vertebra P1699.1 8810 K.

Table B.11 Landmark Measurements for P 1699.1 8810 K

Landmark Locations	Measurements (mm)
BFcr	130.56
HFcr	130.02
BFcd	133.98 (i)
HFcd	130.35 (i)
BPtr	174.49 (i)
H	232.49 (i)
PL	76.24 (i)



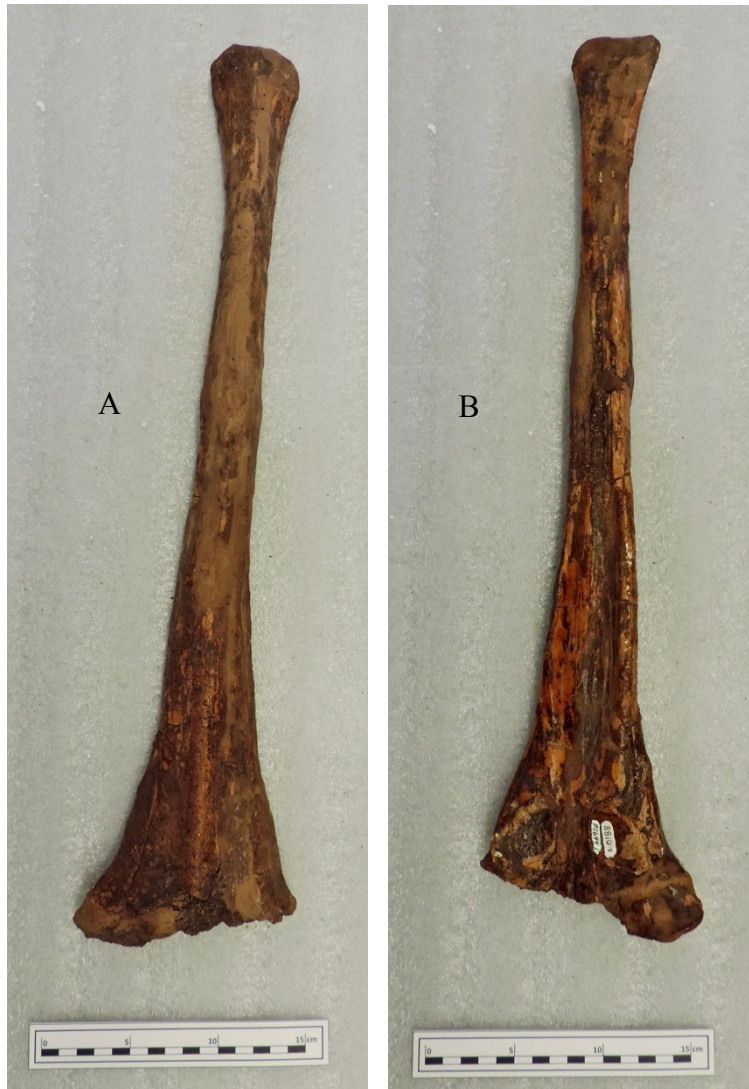


Figure B.12 Cranial (A) and caudal (B) sides of a spinous process P 1699.1 8810 D. Maximum length of the spinous process is 516 mm.



Figure B.13 Two sides of incomplete rib 1.

Table B.12 Rib 1 Measurements

Landmark Location	Measurement (mm)
Medial Length	610 (i)
Rib Tuber to Lateral Terminus	615 (i)
Longest length	640 (i)



Figure B.14 Rib 2 cranial (A) and caudal (B) sides.

Table B.13 Rib 2 Measurements

Landmark Location	Measurement (mm)
Medial Length	965
Rib Tuber to Lateral Terminus	1001
Longest Length	1007



Figure B.15 Lingual (A), buccal (B), and occlusal (C) sides of the right mandible.

Table B.14 Measurements for the Mandible

Landmark Locations	Measurements (mm)
Goc- Id	548.35
Cr- Id	456.05
Occlusal Surface 1	122.39
Occlusal Surface 2	241.1
3	243.55
4	330.45
5	438.35 (i)
6	283.4
19	501.6 (i)
20	383.45
21	383
22a	173.36
22b	264.68



Figure B.16 Right Scapula lateral view.

Table B.15 Measurements for the Scapula

Landmark Locations	Measurements (mm)
HS	984 (i)
DHA	935 (i)
Ld	776 (i)
SLC	302.34
GLP	316.25
LG	231.92
BG	150.51

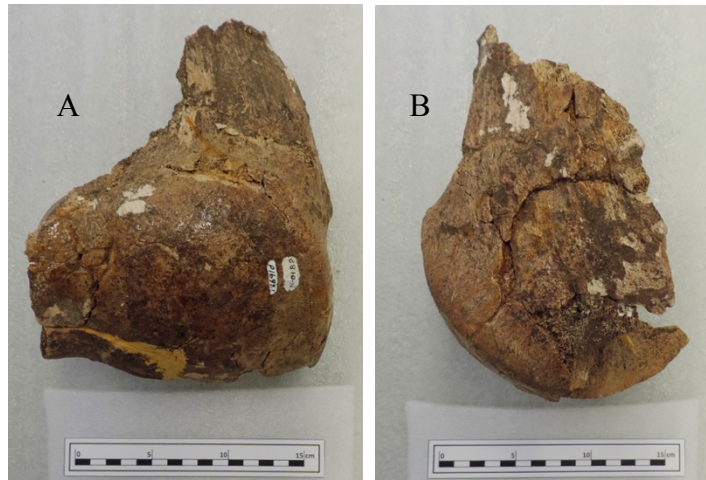


Figure B.17 Right distal humerus caudal (A) and lateral (B) views. No measurements presented due to incompleteness.



Figure B.18 Right distal radius inferior (A) and lateral (B) views. No measurements presented due to incompleteness.

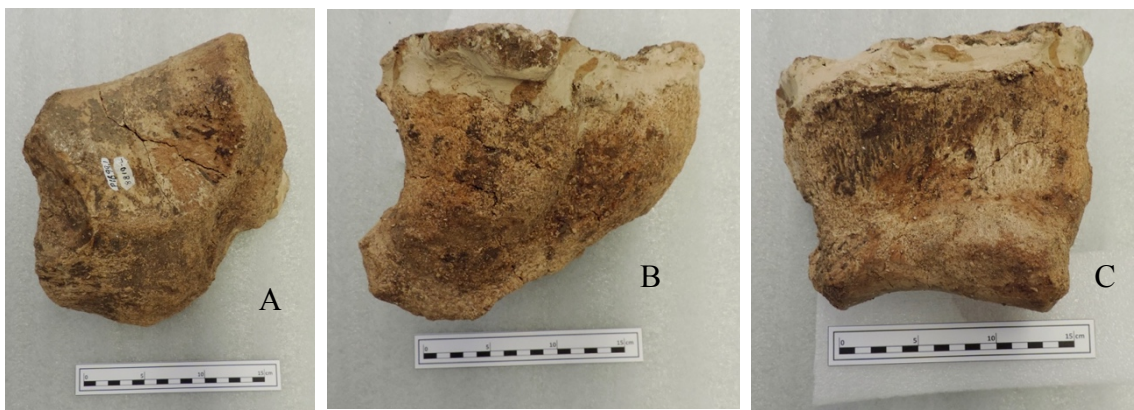


Figure B.19 Right distal ulna inferior (A), lateral (B), and caudal (C) views. No measurements presented due to incompleteness.



Figure B.20 Right articulated forelimb, cranial (A) and caudal (B) views.

Table B.16 Articulated Forelimb Measurements

Landmark Locations	Measurements (mm)
Max Height	371.5
Max Width	257.49 (i)
Height of Tarsals	173.69 (i)
Max Length of Articulation	477.5



Figure B.21 Right unfused femur from caudal (A), medial (B), and cranial (C) views.

Table B.17 Right Femur Measurements

Landmark Locations	Measurements (mm)
GL	1149
GLC	-
Bp	371.4
BTr	-
DC	-
SD	188.68
CD	495
Bd	252.5



Figure B.22 Right articulated hindfoot including tarsals.

Table B.18 Right Hindlimb Measurements

Landmark Locations	Measurements (mm)
Max Height	174
Max Width	202.36
Height of Tarsals	183.36 (i)
Max Length of Articulation	273



Figure B.23 Tusk photographed on shelf due to fragile state. The three photographs depict a single tusk at different position along its length.

Table B.19 Tusk Measurements

Landmark Locations	Measurements (mm)
Lateral Length	2520 (i)
Medial Length	2015 (i)
Circumference	555

References Cited

- Acton, D.F., G.A. Padbury, C.T. Stushnoff
1998 *The Ecoregions of Saskatchewan*, edited by Saskatchewan Environment and Resource Managment. Canadian Plains Research Centre, University of Regina.
- Agenbroad, Larry D.
2005 North American Proboscideans: Mammoths: The state of Knowledge, 2003. *Quaternary International* 126-128:73-92.
- Agogino, G.
1997 An Early Attempt to Remove Preservatives from Bon. *Southwestern Lore* 63(3):42-43.
- Albritton, Claude C., Jr.
1966 Stratigraphy of the Domebo Site. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie- Plains*, edited by Frank C. Leonhardy. pp: 11-13. Contributions of the Museum of the Great Plains No. 1, Lawton.
- Álvares-Lao Diego J. and Marcos Méndez
2011 Ontogenetic Changes and Sexual Dimorphism in the Mandible of Adult Woolly Mammoths (*Mammuthus primigenius*). *Geobios* 44:335-343.
- Anderson, Adrain
1962 The Cooperton Mammoth: A Preliminary Report. *Plains Anthropologist* 7(16):110-112.

1975 The Cooperton Mammoth: An Early Man Bone Quarry. *Great Plains Journal* 14:131-173.
- Averianov, A.,
1996 Sexual Dimorphism in the Mammoth Skull, Teeth, and Long Bones. In *The Proboscidea, Evolution and Paleoecology of Elephants and Their Relatives*, edited by Jeheskel Shorhani and Pascal Tassy, pp.260–267. Oxford University Press, Oxford.
- Behrensmeyer, Anna K.
1978 Taphonomic and Ecologic Information from Bone Weathering. *Paleobiology* 4(2):150-162.
- Bennett, Matthew R. and Neil F. Glasser
2009 *Glacial Geology: Ice Sheets and Landforms*. 2nd ed. Wiley-Blackwell, West Sussex.
- Birkeland, Peter W.
1999 *Soils and Geomorphology*. 3rd ed. Oxford University Press, New York.

- Boldurian, Anthony T., and John L. Cotter
1999 *Clovis Revisited: New Perspectives on Paleoindian Adaptations from Blackwater Draw, New Mexico*. The University Museum, University of Pennsylvania, Philadelphia.
- Brady, Nyle C. and Ray R. Weil
2002 *The Nature and Properties of Soils*. 13th ed. Prentice Hall, Upper Saddle River, N.J.
- Brunswick, Robert H.
2007 New Interpretations of the Dent Mammoth Site. In *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*. Edited by Robert H. Brunswick and Bonnie L. Pitblado, University Press of Colorado, Boulder, Colorado.
- Bryson, Reid A.
1980 Ancient Climes on the Great Plains. *Natural History*, 89:64-73.
- Byers, David A.
2002 Taphonomic Analysis, Associational Integrity, and Depositional History of the Fetterman Mammoth, Eastern Wyoming, U.S.A. *Geoarchaeology: An International Journal* 17(5):417-440.
- Byers, Steven N.
2011 *Introduction to Forensic Anthropology*. Pearson Education Inc. New Jersey.
- Christiansen, Earl A.
1959 Glacial geology of the Swift Current area. *Saskatchewan Department of Mineral Resources*, Report 32, Regina.

1965 Ice Frontal Positions in Saskatchewan. *Saskatchewan Research Council*, Map No. 2, Geology Division, Regina.

1979 The Wisconsinan Deglaciation of Southern Saskatchewan and Adjacent Areas. *Canadian Journal of Earth Sciences* 16(4):913-938.
- Clayton Lee and Stephan R. Moran
1982 Chronology of Late Wisconsinan Glaciation in Middle North America. *Quaternary Science Reviews*, 1:55-82.
- Collins, Michael B., Dennis J. Stanford, Darrin L. Lowery, and Bruce A. Bradley
2014 North America before Clovis: Variance in Temporal/Spatial Cultural Patterns, 27,000- 13,000 cal yr BP. In *Paleoamerican Odyssey*. Edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 521-540. Texas A&M University Press, Texas.
- Colton, R.B., R.W. Lemke, and R.M. Lindvall
1961 Glacial Map of Montana East of the Rocky Mountains. *United States Geological Survey*, Miscellaneous Geological Investigations Map 1-327.

- D'Errico, Francesco, and Paola Villa
1997 Holes and Grooves: the Contribution of Microscopy and Taphonomy to the Problem of Art Origins. *Journal of Human Evolution* 33:1-31.
- DeVries, B.,
1963 An Investigation of a Late-Glacial Deposit from the Missouri Coteau in Saskatchewan. M.S. Thesis, Department of Biology, University of Manitoba, Winnipeg.
- Dick, Herbert W., and Bert Mountain
1960 The Claypool Site: a Cody Complex Site in Northeastern Colorado. *American Antiquity* 26(2):223-235.
- Dominguez-Rodrigo, M., S. de Juana, A.B. Galan, and M. Rodriguez
2009 A New Protocol to Differentiate Trampling Marks from Butchery Cut Marks. *Journal of Archaeological Science*, 36:2643-2654.
- Dyck, Ian
1983 The Prehistory of Southern Saskatchewan. In *Tracking Ancient Hunters: Prehistoric Archaeology in Saskatchewan*. Edited by Henry T. Epp and Ian Dyck, Saskatchewan Archaeological Society, Regina, Saskatchewan.
- Dyke, Arthur S.
2004 An Outline of North American Deglaciation with Emphasis on Central and Northern Canada. *Developments in Quaternary Science*, 2:272-424.
- Dyke, S. and Victor K. Prest
1987 Late Wisconsinan and Holocene History of the Laurentide Ice Sheet. *Géographie physique et Quaternaire* 41(2):237-263.
- Dyke, A.S., J.T. Andrews, P.U. Clark, J.H. England, G.H. Miller, J. Shaw, and J.J. Veillette
2002 The Laurentide and Innuitian Ice Sheets During the Last Glacial Maximum. *Quaternary Science Reviews* 21:9-31.
- Dyke, A.S., A. Moore, and L. Robertson
2003 Deglaciation of North America. *Geological Survey of Canada Geoscan*, Open File 1574, Government of Canada, Electronic Document :
<http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb>, accessed August 4, 2016.
- Edmunds, F.H.
1962 *Recession of Wisconsinan Glacier from central Saskatchewan*. Report 67, Saskatchewan Department of Mineral Resources, Regina.
- Elson J.A.
1958 Pleistocene History of Southwestern Manitoba. In *Guidebook: Ninth Annual Field Conference* edited by W.M. Laird, R.W. Lemk, and M. Hansen, North Dakota Geology Survey, Miscellaneous Series 10:62-73.

- Evans, C.V. and J.A. Freeland
2000 Wetland Soils of Basins and Depressions of Glacial Terrains. In *Wetland Soils: Genesis, Hydrology, Landscapes, and Classification*, edited by J. L. Richardson and M. J. Vepraskas. Lewis Publishers, Boca Raton.
- Fisher, Daniel C.
1984 Taphonomic Analysis of Late Pleistocene Mastodon Occurrences: Evidence of Butchery by North American Paleo-Indians. *Paleobiology* 10(3):338-357.
- Frison, George C.
2004 *Survival by Hunting: Prehistoric Human Predators and Animal Prey*. University of California Press, Berkeley.
- Frison, George C., and Lawrence C. Todd
1986 *The Colby Mammoth Site: Taphonomy and Archaeology of a Clovis Kill in Northern Wyoming*. University of New Mexico Press, New Mexico.
- Graham, Russell W., C. Vance Haynes, Donald Lee Johnson, and Marvin Kay
1981 Kimmswick: A Clovis-Mastodon Association in Eastern Missouri. *Science*, 213(4512):1115-1117.
- Grayson, Donald K. and David J. Meltzer
2002 Clovis Hunting and Large Mammal Extinction: A Critical Review of the Evidence. *Journal of World Prehistory*, 16(4):313-359.
- Hall, Jonathan B.
2009 *Pointing it Out: Fluted Projectile Point Distributions and Early Human Populations in Saskatchewan*. Master's thesis. Department of Archaeology, Simon Fraser University, Burnaby.
- Hannus, Lucien Adrien
1985 *The Lange/Ferguson Site- An Event of Clovis Mammoth Butchery with the Associated Bone Tool Technology: The Mammoth and its Track*. Ph.D. dissertation, Department of Anthropology, University of Utah, Salt Lake City.
- 1990 The Lange-Ferguson Site: A Case for Mammoth Bone Butchering Tools. In *Megafauna and Man: Discovery of America's Heartland*. Edited by Larry D. Agenbroad, Jim I. Mead and Lisa W. Nelson. The Mammoth Site of Hot Springs, South Dakota, Inc. Scientific Papers, Vol. 1, Hot Springs.
- Haury, Emil W., Ernst Antevs, and John F. Lance
1953 Artifacts with Mammoth Remains, Naco, Arizona. *American Antiquity* 19(1):1-24.

Haury, Emil W., E.B. Sayles, and William W. Wasley

1986 The Lehner Mammoth Site, Southeastern Arizona. In *Emil W. Haury's Prehistory of the American Southwest*. Edited by J. Jefferson Reid and David E. Doyel. pp 99-145. University of Arizona, Tucson.

Haynes, Gary

1988 Evidence of Carnivore Gnawing on Pleistocene and Recent Mammalian Bones. *Paleobiology*, 6(3):341-351.

1991 *Mammoths, Mastodonts, and Elephants: Biology, Behavior, and the Fossil Record*. Cambridge University Press, Cambridge.

Haynes, C. Vance

1966 Elephant Hunting in North America. *Scientific American* 214:104-112.

1992 Contributions of radiocarbon dating to the geochronology of the peopling of the New World. In *Radiocarbon After Four Decades: An Interdisciplinary Perspective*, edited by R.E. Taylor, A. Long, and R.S. Kra, pp. 355-74 Springer-Verlag, New York.

1993 Clovis-Folsom geochronology and climatic change. In *From Kostenki to Clovis: Upper Paleolithic-Paleo-Indian Adaptations*, edited by O. Soffer and N.D. Praslov, pp. 219-236. Plenum Press, New York.

Haynes, C. Vance Jr.

2007 Radiocarbon Dating at Murray Springs and Curry Draw. In *Murray Springs: A Clovis Site with Multiple Activity Areas in the San Pedro Valley, Arizona*, edited by C. Vance Haynes, Jr. and Bruce B. Huckell. pp: 229-239 The University of Arizona Press, Tucson.

Hemmings, E. Thomas

2007 Buried Animal Kills and Processing Localities, Areas 1-5. In *Murray Springs: A Clovis Site with Multiple Activity Areas in the San Pedro Valley, Arizona*. Edited by C. Vance Haynes Jr., and Bruce B. Huckell. pp. 83-137. The University of Arizona Press, Tucson, Arizona.

Hemmings, E. Thomas, and C. Vance Haynes

1969 The Escapule Mammoth and Associated Projectile Points, San Pedro Valley, Arizona. *Journal of the Arizona Academy of Science* 5(3):184-188.

Hester, James J.

1972 *Blackwater Locality No. 1: A Stratified, Early Man Site in Eastern New Mexico*. No. 8. Fort Burgwin Research Center Inc. Southern Methodist University, New Mexico.

Holen, Steven R.

2006 Taphonomy of Two Last Glacial Maximum Mammoth Sites in the Central Great Plains of North America: A Preliminary Report on La Sena and Lovewell. *Quaternary International*, 142-143:30-43.

2007 The Age and Taphonomy of Mammoths at Lovewell Reservoir, Jewell County, Kansas, USA. *Quaternary International*, 169-170:51-63.

Holen, S.R., and D.W. May

2002 The La Sena and Shaffert mammoth sites: history of investigations, 1987-1998. In *Medicine Creek: Seventy Years of Archaeological Research* edited by D. Roper. The University of Alabama Press, Tuscaloosa and London.

Holen, Steven R. and Kathleen Holen

2011 Evidence of a Human Occupation of the North American Great Plains During the Last Glacial Maximum. In *IV Simposio Internacianal: El hombre temprano en America* edited by J.C. Jimenez Lopez, C. Serrano Sanchez, A Gonzalez Gonzalez, and F.J. Aguilar Arellano, pp 85-105. Instituto Nacional de Anthropologia and Historia, Mexico City.

2014 The Mammoth Steppe Hypothesis: The Middle Wisconsin (Oxygen Isotope Stage 3) Peopling of North America. In *Paleoamerican Odyssey*, edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters Texas A&M University Press, Texas.

Holliday, Vance T.

2000 The Evolution of Paleoindian Geochronology and Typology on the Great Plains. *Geoarchaeology: An International Journal*, 15(3):227-290.

Holliday, Vance T., C. Vance Haynes Jr., Jack L. Hofman, David J. Meltzer

1994 Geoarchaeology and Geochronology of the Miami (Clovis) Site, Southern High Plains of Texas. *Quaternary Research* 41:234-244.

Holliday, Vance T., Eileen Johnson, Herbert Haas and Robert Stuckenrath

1983 Radiocarbon Ages From the Lubbock Lake Site, 1950-1980: Framework for Cultural and Ecological Change on the Southern High Plains. *Plains Anthropologist* 28(101):165-182.

Holliday, Vance T., and D. Shane Miller

2014 The Clovis Landscape. In *Paleoamerican Odyssey*. Edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 221-246. Texas A&M University Press, Texas.

Howard, Calvin D.

1990 The Clovis Point: Characteristics and Type Description. *Plains Anthropologist*, 35(129):255-262.

- Jachmann, H.
1988 Estimating Age in African Elephants: A Revision of Laws' Molar Evaluation Technique. *African Journal of Ecology*, 26:51-56.
- Johnson, Eileen
2006 The Taphonomy of Mammoth Localities in Southeastern Wisconsin (USA). *Quaternary International*. 142-143: 58-78.

2007 Along the Ice Margin- The Cultural Taphonomy of Late Pleistocene Mammoth in Southeastern Wisconsin (USA). *Quaternary International* 169-170:64-83.
- Joyce, Daniel J.
2006 Chronology and New Research on the Schaefer Mammoth (*Mammuthus primigenius*) site, Kenosha County, Wisconsin, USA. *Quaternary International* 142-143:44-57.

2014 Pre-Clovis Megafauna Butchery Sites in the Western Great Lakes Region, USA. In *Paleoamerican Odyssey*, edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters Texas A&M University Press, Texas.
- Kahlke, Ralf-Dietrich
2015 The maximum Geographic Extension for Late Pleistocene *Mammuthus primigenius* (Proboscidea, Mammalia) and its Limiting Factors. *Quaternary International*, 379:147-154.
- Kehew, Alan E., and James T. Teller
1994 History of Late Glacial Runoff Among the Southwestern Margin of the Laurentide Ice Sheet. *Quaternary Science Reviews* 13:859-877.
- Kehoe, Thomas F.
1964 The Kyle Mammoth. *Saskatchewan Archaeology Newsletter*, 8:1-4.
1966 The Distribution and Implications of Fluted Points in Saskatchewan. *American Antiquity* 31(4):530-539.
- Klassen, R.W.
1989 Quaternary Geology of the Southern Canadian Interior Plains. In *Quaternary Geology of Canada and Greenland*, edited by R. J. Fulton, pp. 138-174. vol. Geological Survey of Canada Geology of Canada No. 1. Geological Survey of Canada, Ottawa.
- Kornfeld, Marcel, George C. Frison and Mary Lou Larson
2010 *Prehistoric Hunter-Gatherers of the High Plains and Rockies*. 3rd ed. Left Coast Press Inc. Walnut Creek.
- Kreutzer, Lee Ann
1988 Megafaunal Butchering at Lubbock Lake, Texas: A Taphonomic Reanalysis. *Quaternary Research* 30:221-231.

- Krzeminska, Alina, Piotr Wojtal, and Marin Oliva
2015 Pathological Changes on Woolly mammoth (*Mammuthus primigenius*) Bones: Holes, Hollows and Other Minor Changes in the Spinous Processes of Vertebrae. *Quaternary International* 359-390:178-185.
- Larramendi, Asier
2015 Shoulder Height, Body Mass and Shape of Proboscideans *Acta Palaeontologica Polonica*, in press.
- Laws, R.M.
1966 Age Criteria for the African Elephant, *Loxodonta A. Africana*. *East African Wildlife Journal* 4:1-37.
- Leonhardy, Frank C. and Adrian D. Anderson
1966 Archaeology at the Domebo Site. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains*, edited by Frank C. Leonhardy. pp. 14-26. Contributions of the Museum of the Great Plains, No. 1, Lawton.
- Lister Adrian M.
1999 Epiphyseal Fusion and Postcranial Age Determination in the Woolly Mammoth *Mammuthus primigenius*. In *Mammoths and the Mammoth Fauna: Studies of an Extinct Ecosystem*, edited by G. Haynes, J. Klimowics, and J.W.F. Reumer, pp 79-88. *Deinsea* 6.
- Maglio, Vincent J.
1973 Origin and Evolution of the Elephantidae. *Transactions of the American Philosophical Society*, 63(3)1-149.
- Malde, Harold E.
1960 Geological Age of the Claypool Site, Northeastern Colorado. *American Antiquity* 26(2):236-243.
- McCallum, K.J. and J. Wittenberg
1968 University of Saskatchewan Radiocarbon Dates V. *Radiocarbon*, 10(2):365-378.
- McDonald, Barrie C., and William W. Shilts
1975 Interpretation of Faults in Glaciofluvial Sediments. In *Glaciofluvial and Glaciolacustrine Sedimentation*, edited by Alan V. Jopling and Barrie C. McDonald. Society of Economic Paleontologists and Mineralogists, Special Publication No. 23, Tulsa, Oklahoma
- Mehl, M.G.
1966 The Domebo Mammoth: Vertebrate Paleomortology. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains*, edited by Frank C. Leonhardy. pp. 27-30. Contributions of the Museum of the Great Plains, No. 1, Lawton.

- Miller, D. Shane, Vance T. Holliday and Jordon Bright
2014 Clovis across the Continent. In *Paleoamerican Odyssey*. Edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 207-220. Texas A&M University Press, Texas.
- Morlan, R.E., R. McNeely, S.A. Wolfe, and B.T. Schreiner
2001 *Quaternary Dates and Vertebrate Faunas in Saskatchewan*. Geological Survey of Canada, Open File 3888.
- Olsen, Stanley J.
1979 The American Mastodon and the Woolly Mammoth. *Osteology for the Archaeologist*, 56(3):1-46.
- Olsen, S.L. and P. Shipman
1988 Surface modification on bone: trampling versus butchery. *Journal of Archaeological Science* 15:535-553.
- Overstreet, David F.
1998 Late Pleistocene Geochronology and the Paleoindian Penetration of the Southwestern Lake Michigan Basin. *The Wisconsin Archaeologist* 79(1):28-52.
- Overstreet, David F. and Michael F. Kolb
2003 Geoarchaeological Contexts for Late Pleistocene Archaeological Sites with Human-Modified Woolly Mammoth Remains in Southeastern Wisconsin, U.S.A. *Geoarchaeology: An International Journal*, 18(1):91-114.
- Pettipas, Leo
1975 The Paleo-Indian Prehistory of Saskatchewan. *Saskatchewan Archaeological Newsletter*, 50:1-32.
- Polet, Caroline, Olivier Dutour, Rosine Orban, Ivan Jadin, and Stephane Louryan
1996 A Healed Wound Cause by a Flint Arrowhead in a Neolithic Human Innominate from the Trou Rosette (Furfooz, Belgium). *International Journal of Osteoarchaeology*, 6:414-420.
- Retallick, Harold J.
1966 Geomorphology of the Domebo Site. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains*, edited by Frank C. Leonhardy. pp. 3-10. Contributions of the Museum of the Great Plains, No. 1, Lawton, Oklahoma.
- Ritchie, J.C. and S.P. Harrison
1993. Vegetation, Lake Levels, and Climate in Western Canada During the Holocene. In *Global Climates Since the Last Glacial Maximum*, edited by H.E. Wright Jr., J.E. Kutzbach, T. Webb, III, R.F. Ruddiman, F.A. Street-Perrott, P.J. Bartlein, University of Minnesota Press, Minneapolis pp. 401-414.

- Roberts, Charlotte, and Keith Manchester
2005 *The Archaeology of Disease* 3rd ed. Cornell University Press, Ithaca.
- Rogers, Richard A.
1986 Spurred End Scrapers as Diagnostic Paleoindian Artifacts: A Distributional Analysis on Stream Terraces. *American Antiquity*, 51(2):338-341
- Roth, V. Louise
1984 How Elephants Grow: Heterochrony and the Calibration of Developmental Stages in Some Living and Fossil Species. *Journal of Vertebrate Paleontology*, 4(1):126-145.
- Roth, V. Louise, and J. Shoshani
1988 Dental Identification and Age Determination in *Elephas maximus*. *Journal of Zoology* 214(4):567-588.
- Saunders, Jeffrey J.
2007 Processing Marks on Remains of *Mammuthus columbi* from the Dent Site, Colorado, in Light of Those from Clovis, New Mexico. In *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*, edited by Robert H. Brunswig and Bonnie L. Pitblado, pp-155-184. University Press of Colorado, Boulder.
- Schiffer, Michael B.
1987 *Formation Processes of the Archaeological Record*. University of New Mexico Press, Albuquerque.
- Sellards, E.H.
1938 Artifacts Associated with Fossil Elephant. *Bulletin of the Geological Society of America*, 49:999-1010.
- Shipman, Pat, Daniel C. Fisher, and Jennie J. Rose
1984 Mastodon Butchery: Microscopic Evidence of Carcass Processing and Bone Tool Use. *Paleobiology* 10(3):358-365.
- Soil Classification Working Group
1998 *The Canadian System of Soil Classification*. 3rd ed. National Research Council Research Press, Ottawa.
- Stanford, D. and R.W. Graham
1985 Archaeological Investigations of the Selby Dutton Mammoth Kill Sites, Yuma County, Colorado. *National Geographic Research Report* 19:519-541.
- Turner, R.J.W., Franklin, R.G., Haidl, F.M., Gilboy, C.F., and Clague, J.J.
2004 *Geoscape Southern Saskatchewan* Geological Survey of Canada Miscellaneous Report 84. Electronic Document <http://www.cgenarchive.org/saskatchewan-s-landscape.html>, accessed May 29, 2016.

Von Den Driesch

1976 *A Guide to the Measurement of Animal Bones From Archaeological Sites*. Peabody Museum of Archaeology and Ehtnology, Harvard University, Cambridge.

Waguespack, Nicole M.

2007 Why We're Still Arguing About the Pleistocene Occupation of the Americas. *Evolutionary Anthropology* 16:63-74.

2014 Pleistocene Extinctions: The State of Evidence and the Structure of Debate. In *Paleoamerican Odyssey*, edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters Texas A&M University Press, Texas.

Warnica, James M.

1966 New Discoveris at the Clovis Site. *American Antiquity*, 31(3)Part 1:345-357.

Waters, Michael R., and Thomas W. Stafford, Jr.

2014 The First Americans: A Review of the Evidence for the Late-Pleistocene Peopling of the Americas. In *Paleoamerican Odyssey*. Edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 541-560. Texas A&M University Press, Texas.

Webb, David S.

1992 A Brief History of New World Proboscidea with Emphasis on Their Adaptations and Interactions with Man. In *Proboscidean and Paleoindian Interactions*, edited by John W. Fox, Calvin B. Smith and Kenneth T. Wilkins, pp. 15-34. Baylor University Press, Waco.

Yansa, Catherine H.

1998 Holocene Paleovegetation and Paleohydrology of a Prairie Pothole in Southern Saskatchewan, Canada. *Journal of Paleolimnology* 19:429-441.

2005 Lake Records of Northern Plains Paleoindian and Early Archaic Environments: The "Park Oasis" Hypothesis. *Plains Anthropologist* 52(201):109-144.

2006 The Timing and Nature of Late Quaternary Vegetation Changes in the Northern Great Plains, USA and Canada: A Re-Assessment of the Spruce Phase. *Quaternary Science Reviews* 25:263-281.